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#209 OCTOBER 2022

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Welcome

We're standing on the edge of a new era of Moon missions

As we went to print, there was a keen sense of anticipation on the magazine for the launch of Artemis I. NASA's largest rocket launch for 50 years will set humanity on the path back to the Moon's surface and bring the construction of a space station in lunar orbit one step closer. Turn to Shaoni Bhattacharya's feature on **page 28** to meet the people who are making these ambitious aims a reality, the NASA scientists and engineers behind the Artemis programme.

Those ambitions include establishing a staging post in lunar orbit for crewed missions to Mars. While such close encounters with the Red Planet are a long way off, prospects for observing the planet from here on Earth are steadily improving this month. Mars season is upon us, and there's extra excitement for December's opposition, with a rare occultation by the Moon happening on the same day. To help you make the most of it, Paul Abel's feature on **page 60** has advice on the Mars sights to look out for in the months ahead.

One thing you won't have quite so long to observe is the solar eclipse on 25 October. It's a partial not total eclipse, but it's the first of any kind since June 2021 and so I for one was keen to read Pete Lawrence's observing advice in the Sky Guide on **page 46** and hints on safely photographing the event on **page 76**.

Talking of imaging, do turn to **page 28** where we are proud to present the winning images from the Astronomy Photographer of the Year 2022 – a more stunning crop of astrophotos I have yet to see!

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 20 October.

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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

Online
Visit our website for competitions, astrophoto galleries, observing guides and more

Social media
Follow us on Twitter, Facebook and Instagram for space news, astro images and website updates

Podcasts
Listen to our Radio Astronomy podcasts where the magazine team and guests discuss astro news

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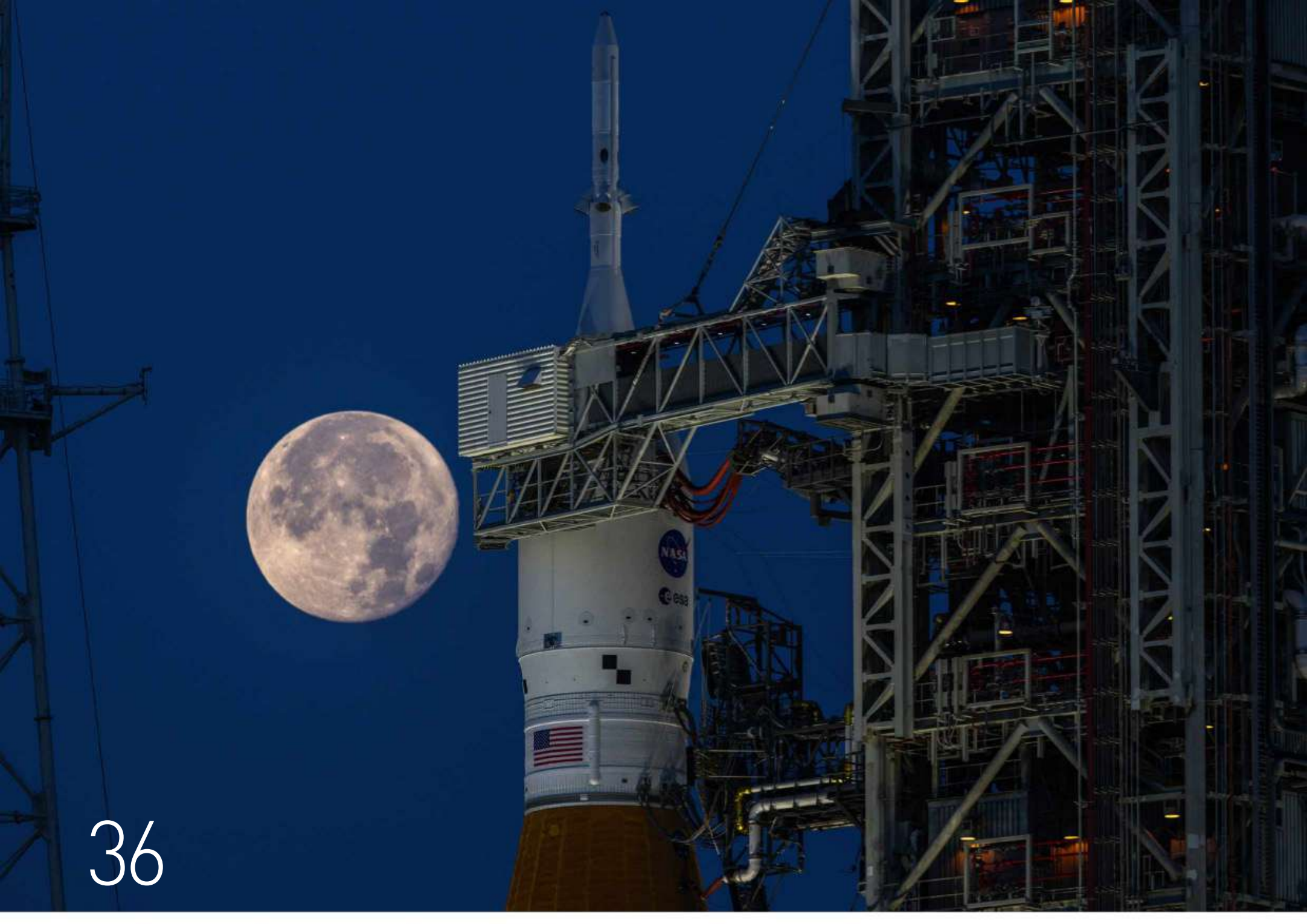

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COVER IMAGE: NASA/BEN SMEGELSKY. THIS PAGE: NASA/BEN SMEGELSKY, WEITANG LIANG, @THESHED_PHOTOSTUDIO, MARY MCINTYRE, SEBASTIAN VOLTMER/CCDGUIDE.COM, JULIAN74/ISTOCK/GETTY IMAGES, BBC, HANNAH ROCHFORD

New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

This month's contributors

Shaoni Bhattacharya

Science journalist

"To hear about the Artemis mission to put the first people on the Moon in 50 years – and then perhaps onto Mars – was incredibly exciting and inspiring!" **Shaoni meets the people making Artemis a reality,** page 36

Paul G Abel

Astrophysicist

"Mars reaches opposition in December, so now's the time to get observing the Red Planet and noting its changing features over the coming months." **Paul tells us about the Mars sights not to miss on** page 60

Jen Gupta

Science communicator

"Photos of the cosmos are a sure-fire way to capture the public's imagination, but there are some images that have also revolutionised our understanding of the Universe." **Jen talks about the pictures that changed us,** page 18

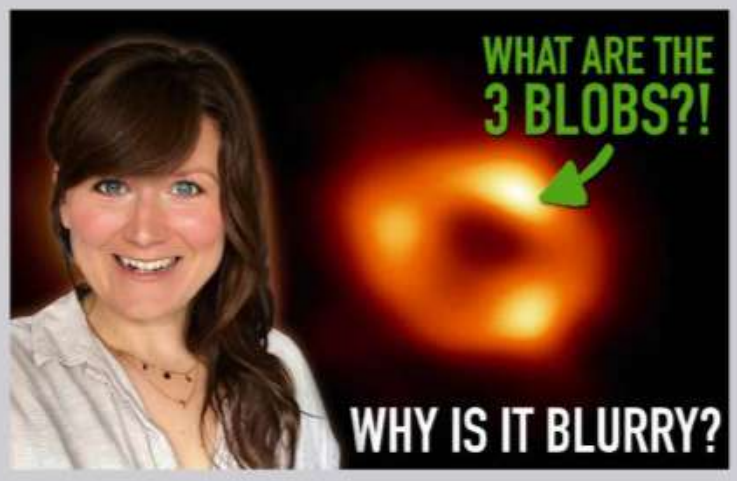
Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/IRIVOWL** to access this month's selection of exclusive Bonus Content

OCTOBER HIGHLIGHTS

Interview: a history of black holes

Dr Becky Smethurst reveals how black holes went from theoretical mysteries to objects we can photograph.



Watch online: *James Webb Road Trip*

The Sky at Night team speak to the UK scientists analysing new data returned by the James Webb Space Telescope.

APY 2022: view our full online gallery

See the winning and runner-up images from the 2022 Astronomy Photographer of the Year competition.

The Virtual Planetarium

Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

THE CARTWHEEL IN SPACE

Another stunning image from the largest space telescope ever launched shows just what this new observatory can do

JAMES WEBB SPACE TELESCOPE, 2 AUGUST 2022

The wonderful Webb Space Telescope delivers again, with this image of the Cartwheel Galaxy in the constellation Sculptor, and its companions, taken using both the scope's near-infrared and mid-infrared cameras.

Formed by a galactic collision 400 million years ago, the Cartwheel Galaxy has a bright inner ring and colourful outer ring, both expanding outward from the centre.

Before the collision shattered it into these beautiful rings, the Cartwheel was a spiral galaxy, and you can see the remains of its arms in the 'spokes' that connect the rings and give the galaxy its name. The red colouration comes from glowing dust rich in hydrocarbons, while the blue dots are pockets of star formation.

MORE ONLINE

Explore a gallery of these and more stunning space images

NASA/ESA/CSA/STSCI/WEBB ERO PRODUCTION TEAM

△ A new star's home

HUBBLE SPACE TELESCOPE,
8 AUGUST 2022

On the outskirts of the Orion Nebula, a swirl in the clouds attracted the Hubble Space Telescope's attention. This luminous region, which surrounds newborn stars, is called a Herbig–Haro object, and its gas is perturbed by stellar winds from the young variable star IX Ori into two major outflows moving in opposite directions.

Beauty from destruction ▷

CHANDRA X-RAY OBSERVATORY,
SPITZER SPACE TELESCOPE,
25 JULY 2022

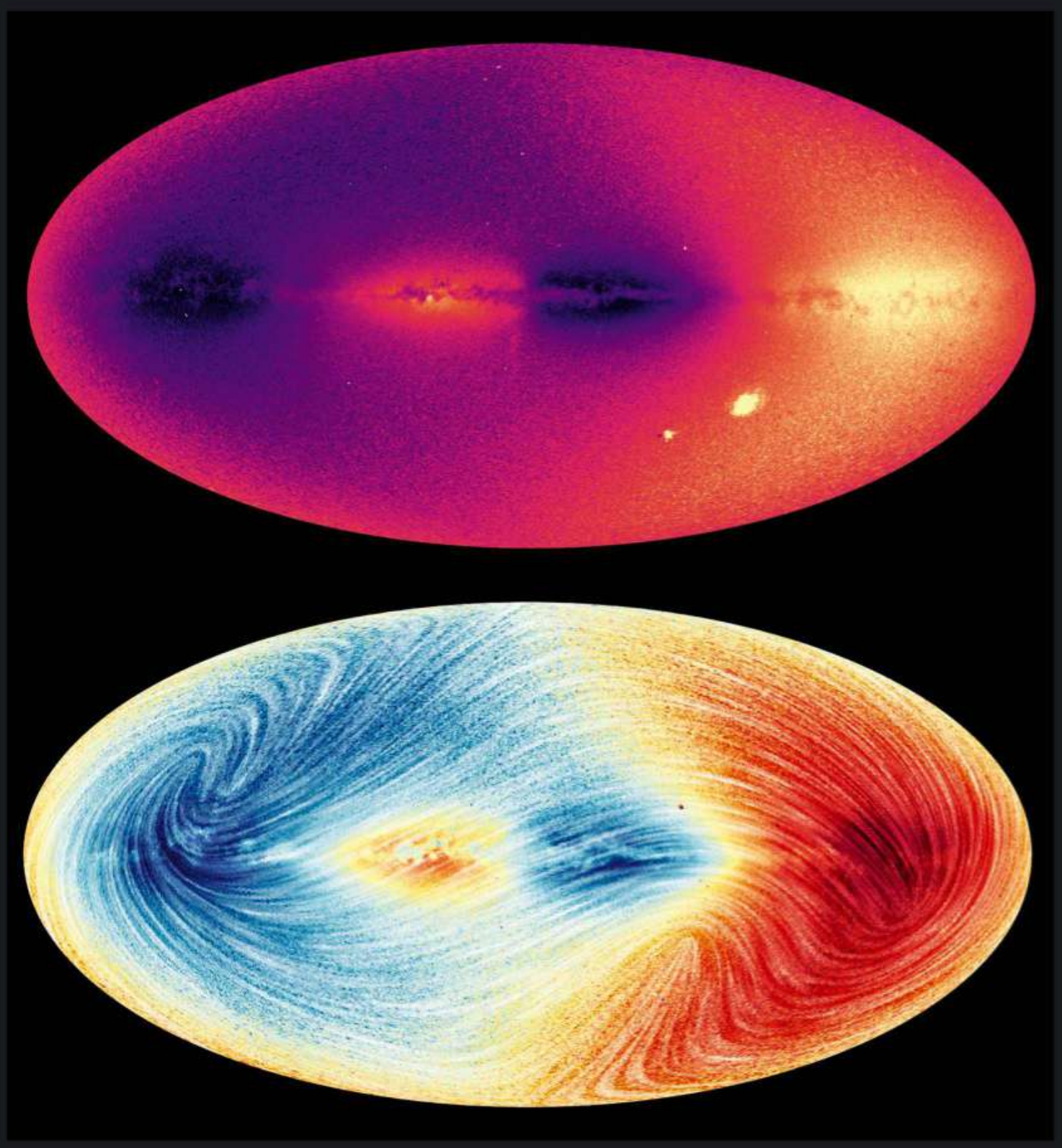
Zeta Ophiuchi's companion star exploded as a supernova, leaving behind this ethereal sculpture made of gas heated to millions of degrees. The blue in the image is X-ray data gathered by the Chandra Observatory, while the red and green come from the retired Spitzer infrared space telescope.

ESA/HUBBLE & NASA/J. BALLY/ACKNOWLEDGMENT: M. H. ÖZSARAÇ, X-RAY: NASA/CXC/DUBLIN INST. ADVANCED STUDIES/S. GREEN ET AL./INFRARED: NASA/JPL/SPITZER, ESA/GAIA/DPAC, NASA/ESA/CSA/JUPITER ERS TEAM/ IMAGE PROCESSING BY RICARDO HUESO (UPV/EHU) AND JUDY SCHMIDT

And yet it moves ▷

GAIA SPACECRAFT, 13 JUNE 2022

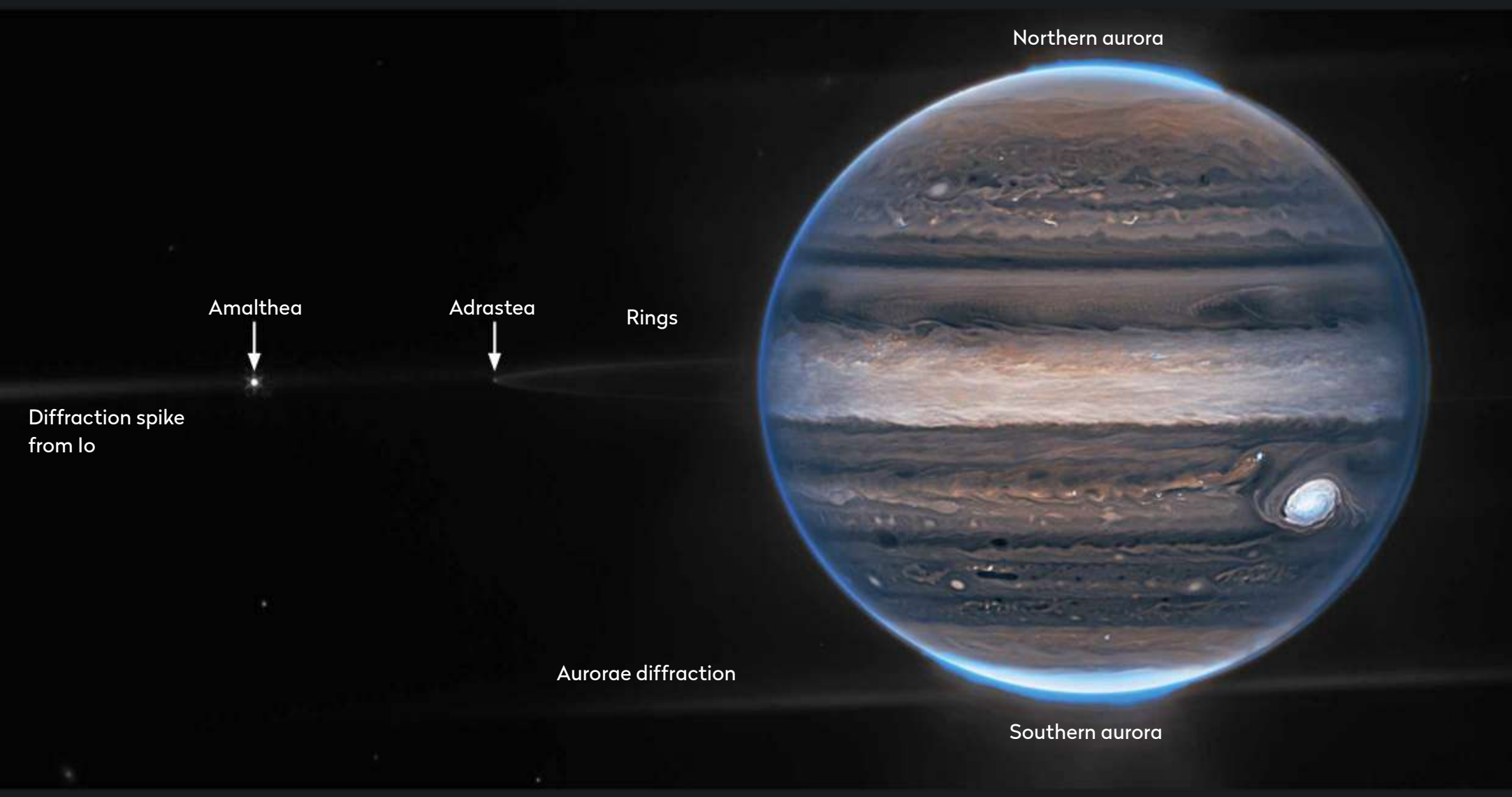
These full-sky images from ESA's Gaia space observatory show (top) the speed at which 30 million Milky Way objects, mostly stars, move toward (bright) or away (dark) from Earth. The second image adds proper motion into the mix, with blue showing the parts of the sky where the average motion of stars is towards us and red is away from us.



▽ Jupiter aglow

JAMES WEBB SPACE TELESCOPE, 22 AUGUST 2022

This is Jupiter and two of its moons as you've never seen them before, in an image processed by citizen scientists Judy Schmidt and Ricardo Hueso Alonso. Most striking are aurorae at the planet's poles, as well as its faint rings and tiny moons Adrastea and Amalthea.



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BULLETIN

Waiting game: excitement around Artemis I's launch was tempered by last-minute technical concerns

NASA/BEN SMEGELSKY

Artemis I takes aim at the Moon

Efforts to get the test mission off the ground hit last-minute snags

At long last, NASA is ready to begin its first foray towards the Moon in 50 years with the launch of Artemis I. The mission is an uncrewed test of the Space Launch System (SLS) heavy launch vehicle and the Orion crew module that will carry future crews to the Moon. But will it make its flight? The initial launch on 29 August was scrubbed after a problem was found on SLS's Engine 3.

"We don't launch until it's right," said NASA administrator Bill Nelson. "I think that this is illustrative that this is a complicated machine. You don't want to light the candle until it's ready to go."

The next launch attempt was on 3 September at 18:17 GMT, after our magazine went to print, with a second on 5 September. If the launch has proceeded, then Orion should now be in lunar orbit. At closest approach, it will come within around 100km of the Moon's surface, before travelling out to 64,000km from the far side, beating the previous distance record set by Apollo 13 by 48,000km. On board, two female-bodied model torsos will test the effects of deep-space radiation on women for the first time. They'll be joined by a UK 'astronaut' – a Shaun the Sheep puppet.

Orion will return to Earth, reentering the atmosphere at around 40,000km/h, using aerobraking and a series of parachutes to slow to 32km/h when it splashes down. The mission will last 35 to 42 days – far longer than any other past human lunar missions or any of the planned future crewed Artemis flights.

"We are testing and stressing the spacecraft in a way that you would never do with a human crew on board. That is the purpose of a test flight," says Nelson. **www.nasa.gov**

To find out more about the Artemis programme, turn to our feature on page 36.

Comment

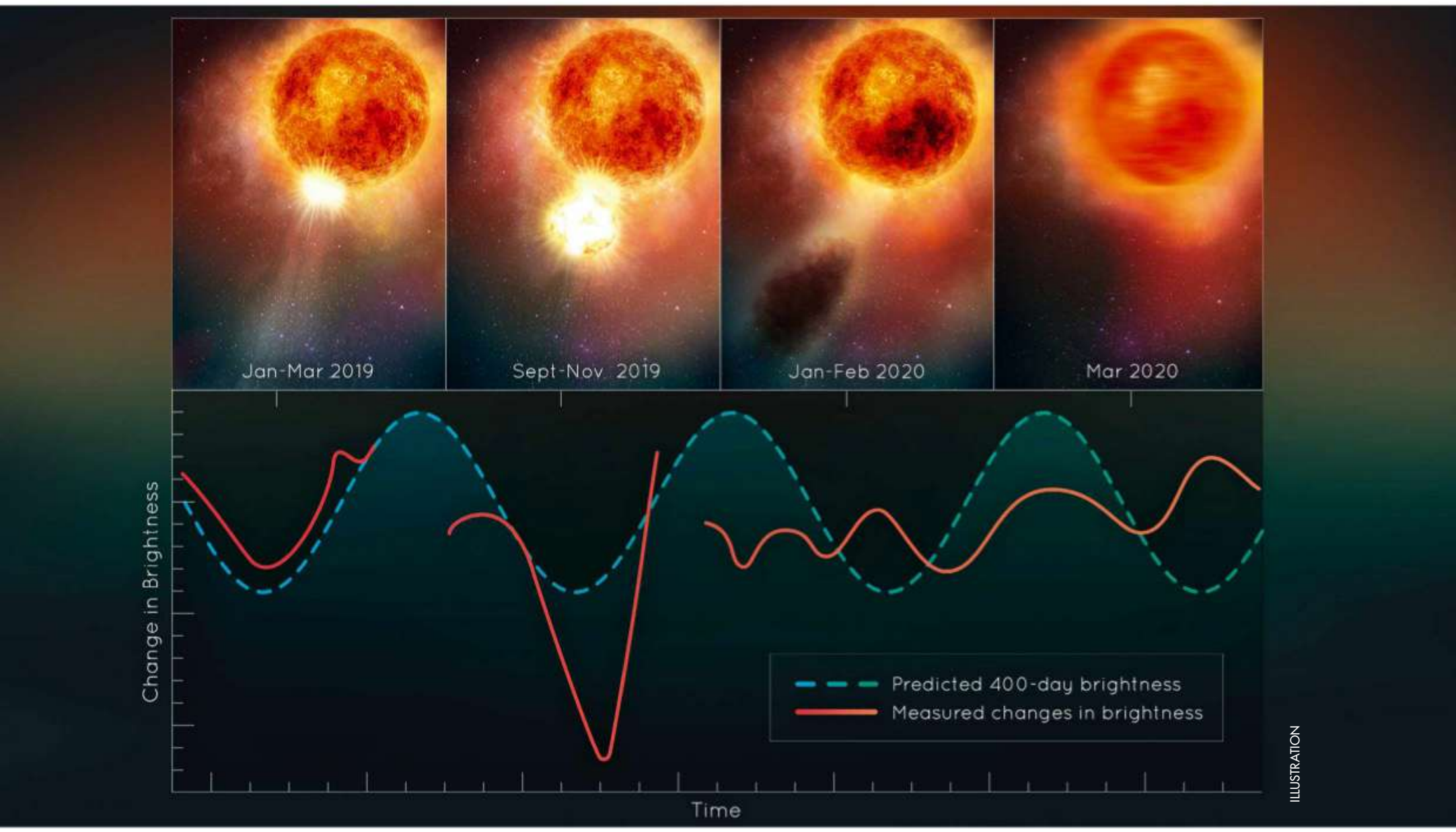
by Chris Lintott

Seeing the giant SLS rocket stacked and ready for launch is thrilling, like nothing we've seen since the last Saturn V missions in the 1970s. For the first time in years there's an exciting, ambitious goal that NASA looks set to meet.

Yet each SLS launch will cost a cool $2.2 billion, putting a limit on how much they can use their new rocket. So famous is Saturn V that it's hard to remember it only flew 13 times. If SLS gets anywhere near that total, I will be very surprised.

If plans for a presence on the Moon do happen, they'll rely on more economical, reusable, rockets like SpaceX's Starship than on SLS, which will – if we're lucky – be a stepping stone on the way to exploring the Solar System.

Chris Lintott co-presents *The Sky at Night*



▲ **Blast off: after blowing its top, the red supergiant star's brightness dimmed dramatically behind the resulting dust cloud**

Betelgeuse's spectacular blow-out

A mass ejection larger than the Moon caused the star's dimming in 2019

Three years ago, amateur astronomers around the world watched as the usually bright light of Betelgeuse dimmed overnight and remained that way for several months. Now a group of astronomers have determined it was caused by a piece of the star's atmosphere being ejected into space.

"We've never before seen a huge mass ejection of the surface of a star," says Andrea Dupree from the Center for Astrophysics, Harvard and Smithsonian, who led the study.

Betelgeuse is a red giant star over 1.6 billion kilometres wide – meaning if it replaced our Sun it would swamp Jupiter and almost reach Saturn. It has ballooned in size as it is approaching the end of its life and will eventually go supernova. Though this is unlikely to happen for the next 10,000 years, it gives astronomers a unique view of a star in its final centuries. Over 200 years of observations have shown that the star's brightness slowly pulses according to a 400-day cycle, but the scale and speed of the 2019 dimming was unprecedented.

Drawing together observations from all over the world, Dupree has determined that material bubbling up within the star blasted off a piece of the photosphere. The ejection had a mass several times that of our Moon – a colossal 400 billion times more than what our Sun typically gives off during coronal mass ejections. As this fractured piece cooled, it formed a dust cloud that blocked Betelgeuse's light from Earth, causing it to appear dimmer.

It also appears that Betelgeuse's 400-day brightness cycle has stopped, or at least paused. Spectral Hubble observations taken by Dupree showed signs that this event and the star's attempts to rebuild its photosphere have disrupted the internal motions that drive the cycle.

"Betelgeuse continues to do some very unusual things right now; the interior is sort of bouncing," says Dupree. "We're left with something we don't completely understand. It's a totally new phenomenon that we can observe directly and can resolve surface details with Hubble. We're watching stellar evolution in real time."

The team will continue to observe the red giant and hope to use the James Webb Space Telescope to watch as the cooling material moves away from the star.

www.hubblesite.org

NASA/ESA/ELIZABETH WHEATLEY (STSCI), NASA/ESA/CSA AND J. OLMSTED/(STSCI), JAXA, NASA/JPL-CALTECH

Hot gas giant WASP-39b in the constellation of Virgo, where the gas was found

ILLUSTRATION

First detection of carbon dioxide on exoplanet

The gas could hold key to tracking down life on other planets

Carbon dioxide has been sniffed out for the first time in the atmosphere of a world beyond our Solar System by the James Webb Space Telescope (JWST).

JWST looked at the starlight streaming through the atmosphere of exoplanet WASP-39b as it passed in front of its star. The telescope was sensitive enough at the right wavelengths that planetary scientists were able to pick out the signatures of water, methane and carbon dioxide.

"Detecting such a clear signal of carbon dioxide on WASP-39b bodes well for the detection of atmospheres on smaller, terrestrial-sized planets," says research lead Natalie Batalha of the University of California, Santa Cruz. The gas can be used to measure the ratio of solids to gases when the planets formed. Perhaps more critically, it is a gas given off by many organisms on Earth, so could help uncover life on distant worlds.

webb.nasa.gov

Ryugu's dust is older than Solar System

Grains of dust from before the Solar System's creation have been found in the samples of asteroid Ryugu brought back by Japan's Hayabusa2 spacecraft.

Asteroids are the leftovers from when the planets formed 4.5 billion years ago and some still contain pre-solar grains. These are the unprocessed remnants of the gas and dust that went on to create our Solar System, and have been found in roughly five per cent of meteorites. Though meteorites provide an easy way to collect asteroid material, they have been contaminated by their time on Earth, unlike the pristine Hayabusa2 samples that were collected directly from the asteroid in 2019.

The international team were keen to see if they could find pre-solar grains in the Ryugu sample and so looked for them using their isotopic ratios. Isotopes are alternate versions of elements that have a slightly different atomic weight. The ratio isotopes occur in is governed by the star they came from, and so the grains can be used to uncover where the material that made our Solar System originated.

Purity test: the 5.4g sample included grains that pre-date our Solar System

www.hayabusa2.jaxa.jp/en

NEWS IN BRIEF

ILLUSTRATION

Mars rocks homeward bound in 2033

Martian samples collected by the Perseverance rover are set to begin their journey to Earth in 2033. NASA has now completed the review phase of its plan, which will use the rover and two recovery helicopters to carry the collection to a Sample Retrieval Lander (due to launch in 2027), that will then send them to the Earth Return Orbiter (2028).

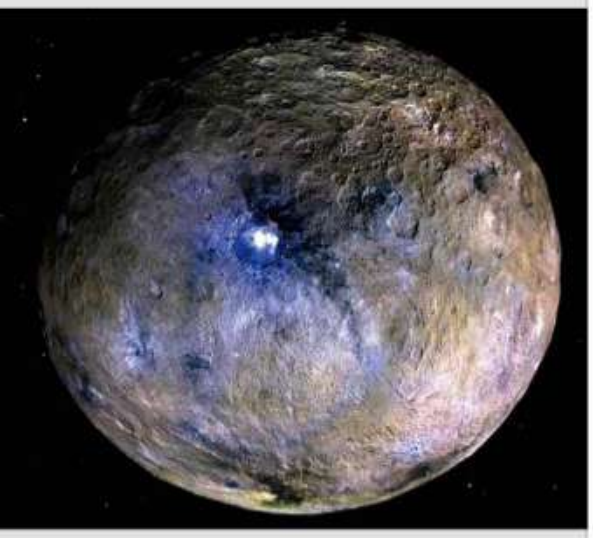
South Korea to the Moon

South Korea's first lunar spacecraft began its journey on 4 August. The Korean Pathfinder Lunar Orbiter, or Danuri, will arrive in lunar orbit in December. It will orbit the Moon 12 times a day, imaging the surface and testing an 'interplanetary internet' for use on future missions.

No dark matter for dwarfs

The movements of dwarf galaxies in Earth's second-closest galaxy cluster indicate they lack dark matter. A new study of the Fornax Cluster led by the University of Bonn suggests that this could be more evidence of an alternate theory of gravity, called modified Newtonian dynamics (MOND).

NEWS IN BRIEF



NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA, STEVEN GIACALONE/UC BERKELEY, NASA/GSFC/ARIZONA STATE UNIVERSITY

Ceres's radioactive heater

Dwarf planet Ceres has a radioactive heart that drives its geological activity, according to a recent set of computer simulations. When the Dawn spacecraft arrived in 2015, it found Ceres was unexpectedly active for such a small world, and it now appears radiation from elements such as uranium has warmed it over time.

Artemis III landing sites

When Artemis III lands in 2025, it will not only be the first time a woman has walked on the Moon but the first visit any human has made to the lunar south pole. On 19 August, NASA revealed its 13 preferred landing sites, all of which are close to the pole and geologically diverse.

Tiangong grows

At the end of July the Chinese Space station, Tiangong, received its first science module, Wentian. After successfully docking, a crew of three taikonauts crossed over on 25 July. The second lab, Mengtian, is due to arrive in October to complete the station.

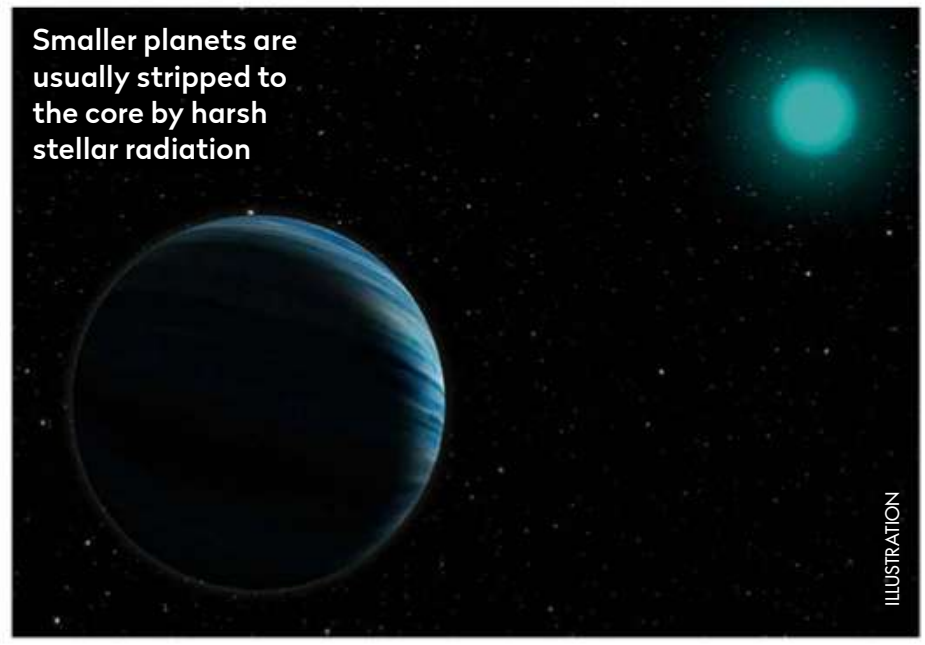
BULLETIN

Hot Neptune found around bright star

Discovery raises puzzle of how planet held onto its atmosphere

The discovery of a Neptune-sized planet around a hot, bright star could help astronomers understand the mysterious lack of Neptune-sized worlds in tight orbits, a phenomenon known as the Hot Neptune Desert.

Though current detection methods mean most exoplanets we know of are close to their stars and larger than Jupiter, it's thought that if a small world gets too close to a star, the radiation will strip its atmosphere away.



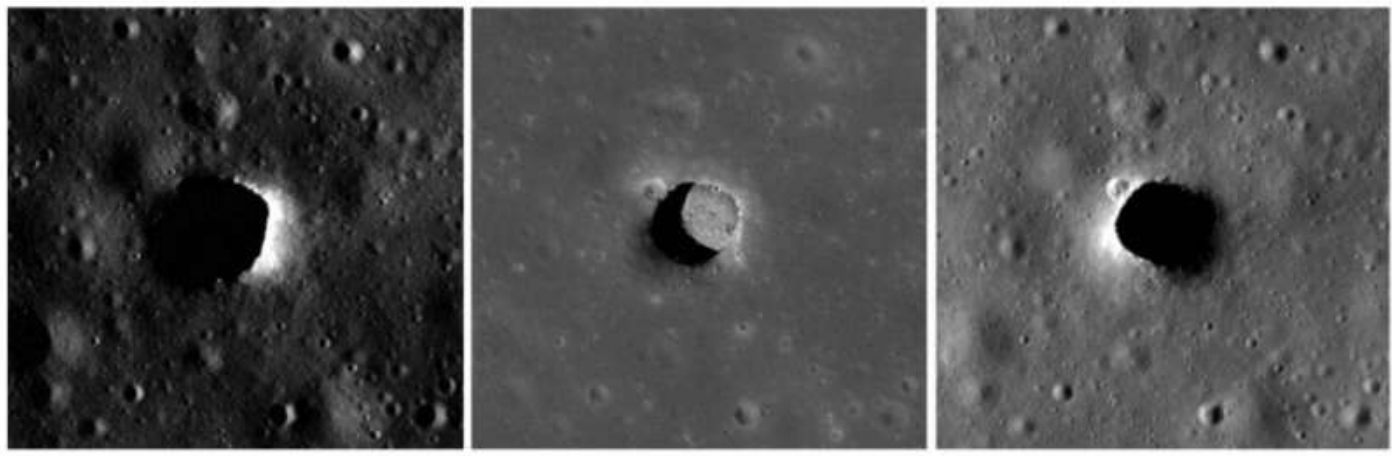
Smaller planets are usually stripped to the core by harsh stellar radiation

ILLUSTRATION

To test this, Courtney Dressing from the University of California, Berkeley looked for Neptune-sized worlds around A-type stars, which are much brighter in ultraviolet than other types of star. "If we're able to look at planets receiving different amounts of light from their star, especially different wavelengths of light, then we can try to see how exactly a planet keeps its atmosphere over time," says Dressing.

www.berkeley.edu

Lunar pits are a pleasant temperature



▲ One pit, three times of day: the 60m-wide Marius Hills pit floor stays a comfy 17°C day and night

The shady bottoms of lunar pits remain at a comfortable 17°C no matter the time of day or night, according to recent observations from the Lunar Reconnaissance orbiter (LRO), a finding that potentially earmarks them as sites for future lunar bases.

Conversely, most of the lunar surface swings wildly between two extremes. During the 15 days of lunar sunshine, surface temperatures can reach as high as 127°C, only to drop to –173°C during the lunar night.

"Lunar pits are a fascinating feature on the lunar surface," says LRO project scientist Noah Petro from the Goddard Space Flight Center. "Knowing that they create a stable thermal environment helps us paint a picture of these unique lunar features and the prospect of one day exploring them."

The pits were first discovered in 2009 by the Japanese Kaguya orbiter and were soon touted as potential sites for a human base, offering protection from cosmic radiation and micrometeorites. Now knowing that they also set the thermostat to room temperature, they seem an even better candidate.

www.lroc.asu.edu

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Our experts examine the hottest new research

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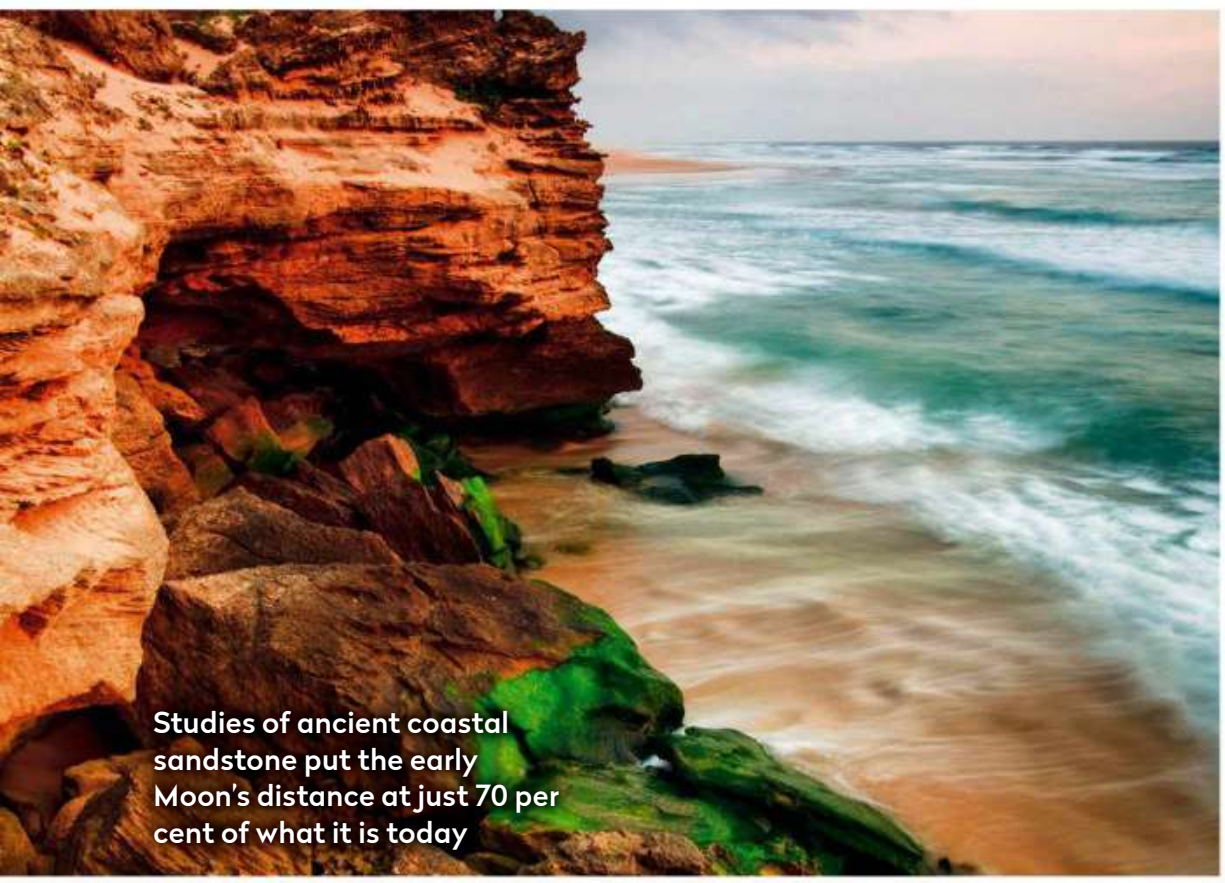


Studies of ancient coastal sandstone put the early Moon's distance at just 70 per cent of what it is today

Tide lines show Moon's move

Marks left by tides 3.2 billion years ago suggest the Moon was once much closer

The gravitational pull of the Moon hauls up Earth's oceans into two bulges on opposite sides of the planet. As Earth rotates beneath these twin bulges, sea levels along the coastlines rise and fall, creating the tides. Much of the world's shores, including around the UK, experience two cycles of high and low tides roughly equal in magnitude every day.

The Sun's gravity also has an effect on the ocean's tides, and roughly twice a month (one lunar orbit), when both the Moon and Sun are in line with Earth, their gravitational effects combine to create a much larger range between high and low water, known as the spring tide. Conversely, when the Moon and Sun are at 90° to each other the tides are weaker, what's called a neap tide.

One factor that has affected the tides over longer timescales is that the rotation of Earth has decelerated over the planet's history, and the Moon has slowly spiralled ever further out in its orbit. Today we know, thanks to measurements taken by a device placed on the Moon by Apollo astronauts, called the Lunar Laser Ranging Experiment, that the Moon is drifting away at a rate of 3.8cm per year.

However, just after the Moon's formation, our satellite circled much, much closer, and each day on Earth was only around four hours long. But what's not clear is exactly how the Earth–Moon system has evolved over the 4.5 billion years since: how have the time Earth takes to rotate and the Moon takes to orbit changed over time? Computer modelling studies widely disagree. What's needed are some actual data points from Earth's deep history.

Sandstone tells a story

And this is where geology can provide crucial insights. Certain kinds of rock were formed from submerged dunes in shallow coastal waters, and show alternating layers of deposited sand and mud, created by strong and weak currents respectively, at different times of the tidal cycle. Tom Eulenfeld and Christoph Heubeck, both at the Institute for Geosciences, Friedrich Schiller University Jena, Germany, have reexamined the oldest example of this in the geological record. It's known as the Moodies Group sandstone in South Africa, and dates back a staggering 3.22 billion years. The thickness of these alternating layers cycles every 15 layers, believed to be due to the varying current strengths over the cycle between spring and neap tides over a month.

"What's not clear is exactly how the Earth–Moon system has evolved since the Moon's formation. Geology can provide crucial insights"

These geological measurements, combined with the application of Kepler's third law of planetary motion, enabled Eulenfeld and Heubeck to reconstruct the rate of Earth's spin and Moon's orbital period at the time these ancient rocks were deposited. They calculate that 3.2 billion years ago the Earth–Moon distance was around 70 per cent of the current value, and that Earth's rotation rate then resulted in a year of about 700 days, with each day lasting around 13 hours. Previous measurements of 650-million-year-old rocks from South Australia place the Earth–Moon distance at 97 per cent of today's separation at that time. With these points to fill in the gaps, computer models can begin to build a much better picture of how the dance of the Moon around Earth has changed over time.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Constraints on Moon's Orbit 3.2 Billion Years Ago from Tidal Bundle Data* by Tom Eulenfeld and Christoph Heubeck. **Read it online at: arxiv.org/abs/2207.05464**

INTERFOTO/ALAMY STOCK PHOTO, X-RAY: NASA/CXC/MTA-EÖTVÖS UNIVERSITY/N. WERNER ET AL/ ILLUSTRATION: NASA/CXC/M. WEISS

Finding the red diamonds in the rough

Could a hunt for galactic leftovers turn into a recipe for the Universe?

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

With the arrival of the first images from the James Webb Space Telescope, astronomers have been spending a lot of time staring at red blobs, trying to make sense of galaxy formation. While we wait for the dust to settle in the race to find the most redshifted systems, to locate the 'furthest ever known galaxy', a team of astronomers led by Krzysztof Lisiecki in Poland have been paying attention to red systems a little closer to home.

Using data from the CIMOS spectrograph on the Very Large Telescope, they have identified a set of nearby 'red nugget' galaxies, the local equivalent of a class of system first discovered in the early Universe. The nuggets deserve their name, being compact and often massive galaxies, with a red colour that reveals an absence of ongoing star formation (which would produce a sprinkling of bright blue stars). Previous work has shown that in the early Universe such systems shine brightly in X-ray, an indication of activity around their supermassive black holes that might account for the lack of star formation.

Building blocks

These jewel-like systems are important because they're thought to merge to make the giant elliptical galaxies we see in local clusters such as Virgo. But studying small, distant systems that are hard to resolve makes it difficult to test that theory. That's why the team set out to find local leftover nuggets that may have survived to the present day. They started with 90,000 galaxies observed by the VLT, picking out those that are massive, small and red.

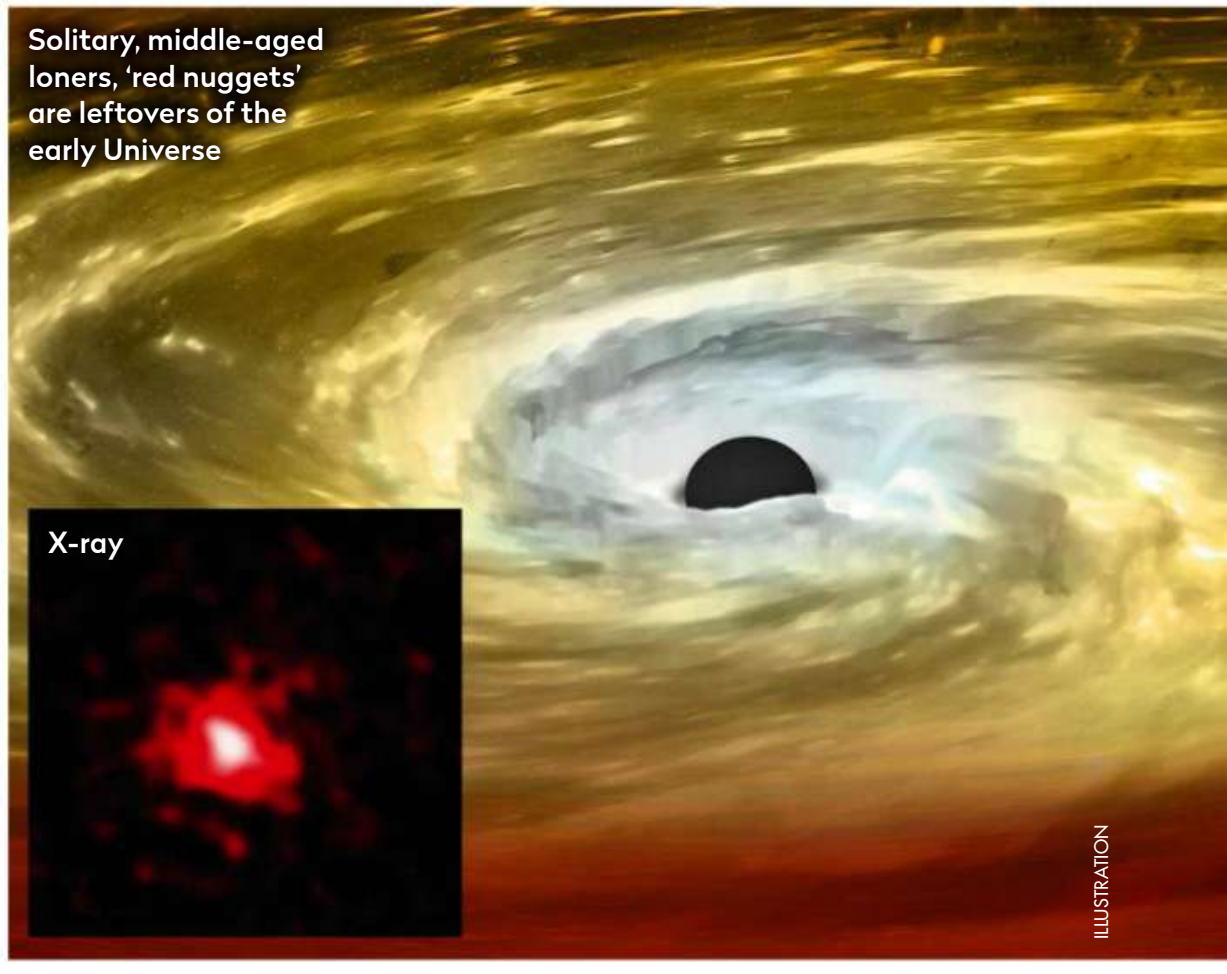
That sounds simple, but each decision made can change the nature of the final collection of galaxies. As an example, the team agonise especially over the definition of 'compact'. We know that red nuggets seem to be especially dense, with plenty of stars packed into a small system, but no one has managed to agree how to translate that into an agreed standard.

"Red nuggets are important because they're thought to merge to make the giant elliptical galaxies we see in local clusters such as Virgo"

The researchers are conservative, keeping only the most nuggety of systems, but that means the result of all that work was a sample of just 77 new nuggets, with redshifts that indicate their light has been travelling towards us for more than six billion years, nearly half the lifetime of the Universe. These new systems thus belong to the Universe's middle age, and there are fewer of them than at the peak of star formation and galaxy assembly four billion years earlier.

If these are the ingredients from which massive elliptical galaxies are made, then the stars in such systems must have formed a long time ago. The most important clue as to the fate of these galaxies is their environments: are they found in massive clusters, or in the empty voids between such structures?

The answer to that question will have to wait for a little while, as the team are still working on it, but the sample they've already assembled is unique. I'm sure they're not the only ones who will be looking at this new collection of red gems scattered across the southern sky.



Chris Lintott was reading... *The First Catalogue of Spectroscopically Confirmed Red Nuggets at z~0.7 from the VIPERS Survey. Linking High-z Red Nuggets and Local Relics* by Krzysztof Lisiecki et al.
Read it online at: arxiv.org/abs/2208.04601

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

In September's episode of *The Sky at Night*, **Jen Gupta** looked at how ever more stunning astronomical photos have revolutionised our understanding of the cosmos

Saying this will probably get me in trouble with my art-loving colleagues, but... I don't think there's a painting in the world that can compare to the beauty of the Universe.

From the classic 'Pillars of Creation' photo taken by the Hubble Space Telescope, to Curiosity Rover's selfies on Mars, and now the stunning first images coming from the James Webb Space Telescope, photographs of (and from) space are a source of inspiration to countless people around the world. But these images aren't just taken so that space nerds like me have pretty pictures to use as our computer backgrounds. Astrophotography has fundamentally changed our understanding of the Universe.

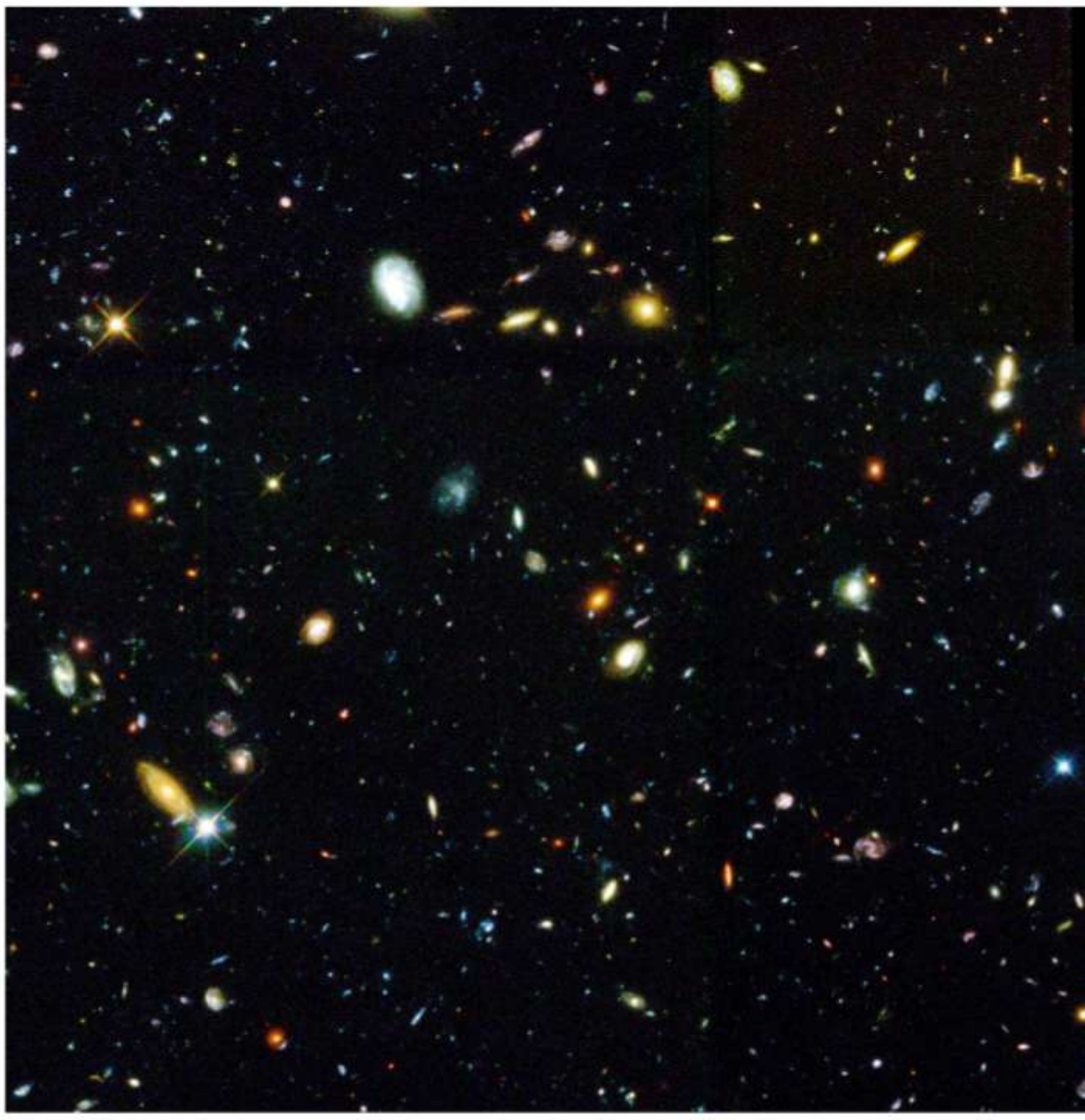
Back in 1883, an amateur astronomer called Andrew Ainslie Common took a long-exposure photograph through his telescope of the Orion Nebula, revealing details in his astrophoto that were normally invisible to the eye. By the early 20th century, astrophotography was commonplace in professional observatories like the Harvard Observatory, where women including Williamina Fleming and Henrietta Swan Leavitt worked as human 'computers', cataloguing and classifying stars in photographic plates. Later, in 1925, Edwin Hubble was examining photographs of the Andromeda Galaxy and spotted Cepheid variable stars, which he then used to calculate the galaxy's distance. His measurements placed the Andromeda Galaxy firmly outside our Milky Way Galaxy, finally resolving the debate about the nature of 'spiral nebulae' (as they were referred to then) and the size of our Universe.

Seeing the *really* big picture

Modern telescopes have moved beyond photographic plates, but the principles remain the same. Point a telescope at something, gather as much light as possible during a long exposure to bring out the details, and perhaps see something unexpected. The Hubble Deep Field image is probably my favourite example of this. In 1995, Robert Williams, director of the Space Telescope Science Institute, pointed Hubble at a tiny, seemingly empty, part of the sky for over 100 hours. The resulting image revealed around 3,000 distant galaxies crammed into a patch of sky the size of a pinhead held at arm's length.

The analysis of astronomical images can also lead us down unexpected paths, as my colleagues at the

◂ Game changer: Andrew Ainslie Common's 1883 image, using a self-made garden telescope, revealed never-before-seen features in the Orion Nebula



▾ Jam-packed: the galaxies unveiled by the Hubble Deep Field boggled minds

R. WILLIAMS (STSCI) THE HUBBLE DEEP FIELD TEAM AND NASA/ESA, MANFRED_KONRAD/ISTOCK/GETTY IAGES, BBC

Jen Gupta is a senior public engagement fellow at Portsmouth University's Institute of Cosmology and Gravitation

University of Portsmouth recently found out during the pandemic. It turns out that computer codes used to automatically find galaxies in astronomical images can also be used to identify cough droplets! The team used fluorescent dye in a 'cough machine' to simulate a person coughing. They then took photos of the resulting cough spray and applied the same computer code to these photographs to pick out where the cough droplets landed. This unusual application of an astronomical tool allowed the team to study how droplets spread from a cough, something that's obviously important in fighting the spread of COVID-19.

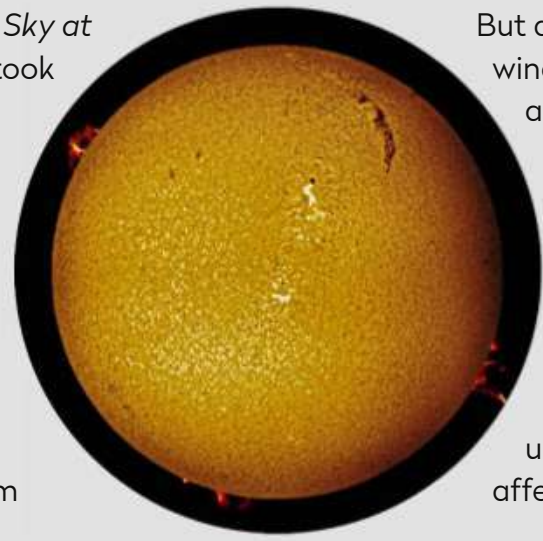
Of course, we need to remember that these beautiful images are not accessible for everyone. A reliance on using imagery to convey how awe-inspiring the cosmos is has the potential to exclude people who are blind and vision-impaired. This is why there's a growing number of projects around the world that are working on ways for people to interact with astronomical observations through the other senses. At the University of Portsmouth we run the Tactile Universe project where we make 3D printed versions of astronomical images so that they can be felt instead of seen, allowing everyone to experience the wonder of the Universe that surrounds us.

Looking back: The Sky at Night

18 October 1979

In this episode of *The Sky at Night*, Patrick Moore took a look towards our nearest star, the Sun. Even in the 1970s, many of the fainter wonders of the night sky were hidden from urban viewers by light pollution, but the Sun was just as visible from the middle of a city as a remote mountainside.

To prove this, he met Peter Gill, an amateur astronomer who observed the Sun using just a small, filtered telescope from the window of his third-floor flat in London. Normally, observing out of the window is inadvisable. The glass will disrupt the view or if it's open, the temperature difference between inside and outside will create turbulent air currents and an unstable image.



▲ The Sun in hydrogen-alpha. The BAA is always on the lookout for such images taken by amateurs

But astronomy through a window is better than no astronomy at all. And solar astronomy is a great option because not only is the temperature less unbalanced during the day, the Sun is large enough that an unstable image won't affect the view too much.

Gill was also a long-time member of the British Astronomical Association. The BAA collects amateur observations here in the UK and sends its results to the World Data Centre in Brussels, where they contribute to humanity's understanding of our star. It welcomes images of the whole disc or specific regions, taken in white light, hydrogen-alpha and calcium K, including hand-drawn observations. Visit **britastro.org/sections/solar** for details.

The Sky at Night: Question Time

The lively – and live – panel discussion on all things astronomy, astrophysics and cosmology returns! In this special episode, presenters Chris, Maggie and Pete, host Dallas Campbell, plus special guests from the worlds of spaceflight and astronomy, face questions from a live studio audience at De Montfort University, Leicester, as part of the 2022 British Science Festival.

BBC Four, **10 October**, 10pm (first repeat will be on BBC Four, **13 October,** time tbc)
Check www.bbc.co.uk/skyatnight for more up-to-date information

▲ Last year's *The Sky at Night: Question Time* at the Civic Theatre, Chelmsford

Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

This month's top prize:
two Philip's titles

The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2023* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

MESSAGE OF THE MONTH

Catching Saturn in a moonbeam

I was observing Saturn on the evening of Thursday 11 August with my girlfriend Lindsay. She's not a serious astronomer but does take an interest in my hobby and loves taking photos of the Moon on her smartphone. She took several shots that evening and whilst most were so-so, one in particular stood out. The 'moonbeam' in the shot could not have been better aimed to point out Saturn, above left of the rising Moon! Right place at the right time, we think.
Tony Bees, via email

A wonderfully serendipitous shot of Saturn, Tony, which has put Van Morrison's song 'Moondance' in our heads! ***– Ed.***

▲ Moonlight perfectly points to Saturn in Lindsay's fabulous shot

Tweet

Barry Clough
@CloughBarry • Aug 22
Stepped outside at 5 this morning, the Moon above me, Venus shining low between the houses and Jupiter with its moons at a steep angle. Another trying day ahead made easier with such sights! @skyatnightmag

Size matters

I enjoyed your feature 'From city lights to deep space' (July 2022 issue, page 28). In it, it's mentioned that certain star clusters and other deep-sky objects can be seen using telescopes of a certain size, but it doesn't mention what type of telescope, whether it's a reflector or a refractor. It may be helpful if both sizes are mentioned. I know scopes vary, but it could be a good guide. Telescope sizes are often mentioned in the magazine, but again not the type.
Bill Foote, Weymouth

Where we have space, we will mention the type of telescope and its aperture. You'll also find a guide to equivalent sizes of refractors and reflectors in the 'Need to know' column on page 45 of every issue. In the case of the feature you mention, Bill, we meant refractors! ***– Ed.***

Shift happens

As the light from distant stars has a redshift, does this mean that the infrared signature of a gas observed for an object with a redshift has its signature redshifted too?
David Mould, via email

That's right, David, all the light from distant stars gets redshifted, meaning that visible becomes infrared, infrared becomes radio and so on, which is why radio telescopes like ALMA are so good for seeing distant galaxies. ***– Ed.***

Photo op

In his letter in your September issue, Ian Sutton mentioned a mystery object he observed on 29 April, which you identified as the deorbit burn of a Russian rocket. I saw it too, 'hovering' above our house as I went outside to check my DSLR that I had

▲ **The blue cloud of a deorbiting rocket burn caught by Philip**

left meteor-hunting. It looked just like a globular cluster, but I knew it was far brighter than M13 or M22. I would have got better images with my 75–300mm zoom lens, but all I could do was divert my camera as was (with a 18mm lens, ISO 6400 and six-second exposure) towards it. The image (above) shows a blue patch to the lower left, the blue colour not being apparent visually.

Philip Pugh, via email

Sky streaks

I live near Basel in Switzerland and on Saturday 20 August I was able to take photos and a video of SpaceX's Starlink satellites passing in space.

Nadia von Burg, Basel, Switzerland

▲ **A pass of Starlink satellites imaged by Swiss reader Nadia**

Sun seekers

Under clear blue skies on Thursday 11 August members of Sunderland Astronomical Society set up their scopes for a solar observing event at Northumberland Park, North Shields, Tyne and Wear, and park-goers were able to safely observe our nearest star. Many were surprised at what they were seeing for the first ▸

ON FACEBOOK

WE ASKED: What would you like to observe or image before the end of the year?

Matthew Terrell I'd like to be able to get enough images to show the rotation of Jupiter over a night, then turn it into a GIF showing the rotation of the planet and its moons. Fingers crossed.

Debz Townsend I'm aiming for Mars – Olympus Mons – using my Celestron NexStar 8SE telescope and new Barlow lens.

Bob Kelly I'm just looking forward to seeing the bright planets (well, Mars, Jupiter and Saturn) in the evening sky. Easier to get at as night starts to arrive earlier.

Brian Smale Anything in focus after getting my telescope properly collimated.

Mick Cassidy Planets when available and, of course, the 'Deep-sky tour' in every edition of the magazine.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I use my Sky-Watcher Evostar 100ED reflector with a 2-inch star diagonal, a binoviewer and a William Optics 9mm eyepiece, but when I try to find the Moon I can't see anything. Help!

ANDY PARRETT

▲ **A Baader SteelTrack Diamond RT could replace the stock focuser**

A binoviewer increases the light path between the focuser and your eye, which must be compensated for by racking the focuser inwards. Unfortunately, the Sky-Watcher Evostar 100ED is not binoviewer-friendly and the most likely problem is that you are unable to move the focuser in far enough to achieve focus.

There are a few things you can do that might allow you to use the binoviewer with your reflector, all of which are designed to reduce the light path length. Try a 1.25-inch mirror star diagonal instead of your current 2-inch diagonal, and ensure that the two eyepiece focus tubes on the binoviewer are racked fully in. You could also attach the supplied Barlow lens to the binoviewer's nosepiece, as this will reduce the light path length – however, this will increase the magnification of the view.

If none of these resolve the issue, then replacing the existing focuser with a lower-profile design like the Baader SteelTrack Diamond RT for Refractors may work.

Steve's top tip

What is coma and how do I fix it?

Coma is an optical aberration that occurs predominately in parabolic reflectors and manifests itself as 'comet-shaped' stars, with their heads pointing inwards towards the centre of the field of view. Although rarely an issue when observing through an eyepiece, coma can become intrusive in images, especially those captured with a large sensor. Coma also becomes more obvious in shorter focal length telescopes and increases with distance from the centre of the mirror, as the aberration affects off-axis light.

Luckily, a coma corrector that fits inside the focus tube will largely correct the aberration.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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▲ Young visitors get a safe look at the Sun thanks to Sunderland Astronomical Society

► time, marvelling at the sunspots and solar prominences that were on view. More than 100 people attended the event, 34 of those were children, and there was lots of enthusiasm and loads of questions. It was a lovely day and a novel way to celebrate the park's 137th birthday!
Graham William Edwards, via email

What's the holdup?

Why are there specific windows for Moon launches? Surely the Moon is above us a lot of the time. After the Artemis launch was called off on Monday 29 August the next window was Friday 2 September. But the Moon moves more by Friday than it will on the days in between, so why isn't there a window of opportunity on Tuesday, Wednesday or Thursday?
Isabelle Mantell, via email

There are several factors considered for an Artemis launch window. The three main ones are: first, the alignment of Earth and the Moon has to put the Moon within reach of the rocket's performance; second, for thermal reasons and solar power production, the Orion crew capsule can't spend more than 90 minutes in eclipse; and third, Orion has to splashdown in daylight. Not all of these requirements will be met every day, hence the limited number of launch windows. ***– Ed.***

Instagram

aman_chokshi • 22 August

The first light of dawn at the South Pole! A spherical panorama with the @nsfgov Amundsen-Scott station on top with brilliant auroras on the bottom. A bittersweet moment to be losing these breathtaking night skies, but looking forward to a magical transition to sunrise. @bbcskyatnightmag @youresa @universetoday @nsfgov @nature

SOCIETY IN FOCUS

With the new observing season upon us, what better time to take your interest in the night sky further and join an astronomical society? **Coventry and Warwickshire Astronomical Society** (CAWAS) meets on the second Friday of every month at Coventry's Earlsdon Methodist Church at 7.15pm. Meetings begin with a welcome from chairman John Davis, followed by Sky Notes, a review of events in the month ahead, the latest astro images from members, Hubble and the James Webb Space Telescope, plus news of what's coming up in the night sky. This is presented by our resident galactic hitchhiker, Mark Edwards. After a refreshment break, the evening concludes with a lecture from a visiting speaker or a member. In October we'll be looking at the Big Bang theory and in November we'll focus on planetary nebulae. We also offer members advice on equipment choices. We look forward to seeing you!
John Fell, CAWAS Committee
► www.covastro.org.uk

▲ Astronomy educator Mary McIntyre delivers her lecture 'Shadows in Space' to CAWAS in August 2022

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

Norman Lockyer Observatory Family Day

Sidmouth, Devon, 16 October, 11am

As part of Sidmouth Science Festival there will be telescopes, a planetarium and meteorology at this famous old observatory dating back over 100 years. Booking not required. Adults £10, children £5. **sidmouth.gov.uk/event/norman-lockyer-observatory-family-day**

International Astronomy Show

Stoneleigh Park, Coventry, 14–15 October

Put together by two amateur stargazers, the show includes lectures from astronomy professor Nial Tavir and eminent science historian Professor Allan Chapman. Show entry £8.50; entry to lectures £6.50. **www.ukastroshow.com**

Coll & The Cosmos Stargazing Weekend

Coll Bunkhouse, Isle of Coll, Inner Hebrides, 22–23 October

A collaboration with Cosmos Planetarium, no extra equipment is needed (though you can bring your own) to enjoy these scientific presentations and the spectacular, dark night sky. £150 for adults, £100 for under-18s. **collbunkhouse.com/dark-skies-coll-cosmos**

Stargazing and Astrophotography

Libanus Mountain Centre, Brecon, Powys, 26 October, 10pm

Join a small group of experienced astronomers and astrophotographers from Dark Sky Wales for three hours to learn the constellations, find deep-sky objects (telescopes provided, or bring your own) and photograph some magnificent objects. £55 per person. **bit.ly/Libanus-stargaze**

Family Space Night

Bredhurst Village Hall, Kent, 28 October, 8pm

An exciting evening of talks and displays from Mid-Kent Astronomical Society about space, astronomy and rockets, with some hands-on activities for young children. Telescopes will be available for observation, weather permitting. **www.midkentastro.org.uk**

Dark Skies Stone Circle Walk

Avebury stone circle, Wiltshire, 30 October, 4:30pm

Part of the Marlborough Dark Skies event, an evening of astronomy inside the stone circle and a guided walk to marvel at the night sky. There will be craft activities too, for younger visitors. Tickets £5 for adults, £3 for children. **www.nationaltrust.org.uk/events**

PICK OF THE MONTH

▲ The popular Fringe event returns for more activities celebrating Yorkshire's dark skies

Dark Skies Fringe Festival

North York Moors and Yorkshire Dales, various venues, 21–30 October

Following a main festival in February comes the popular Fringe event for its third year under the pristine skies of the North York Moors and Yorkshire Dales national parks, which have International Dark Sky Reserve status. The full lineup was yet to be announced at the time of writing, but attendees can expect outdoor adventures in the dark such as night walks, astrophotography and astronomy talks, dark-sky safaris by boat and well-being stargazing retreats. This annual festival is a chance to either expand your knowledge or start your stargazing journey. For those in the South West, there's also a Dark Skies festival taking place on Exmoor on 14–30 October. **www.darkskiesnationalparks.org.uk**

PAUL LANG, ANDY DAWSON PHOTOGRAPHY, STEVE BELL, TONY BARTHOLOMEW, TONY MARSH

Sega Toys Homestar Flux

Satin Black

Imagine enjoying the sky full of stars while sitting on your sofa. This dream can become reality with the Sega Toys series of home planetariums.

Flux is the most powerful and most advanced model available to date. Crafted in a satin-like finish, this powerful star projector is designed to be your first choice home planetarium.

Brilliant glass lenses and our brightest LED to date make everything look vibrant and sharp.
The indicated edges of a lunar crater surrounding the lens finish the look.

SEGA TOYS flx

www.segatoys.space 174GBP

FIELD OF VIEW

Cashing in on the cosmos

Jonathan Powell reflects on the 1910 Halley's Comet panic buying spree

ALEX GREEN/FOLIO

Jonathan Powell is a freelance writer and broadcaster. A former correspondent at BBC Radio Wales, he is currently astronomy columnist at the *South Wales Argus*

They say 'where there's a crowd there's business'. With a huge potential global audience online, the next time inspiration for an innovation flashes like a shooting star, no matter how unlikely-sounding it may be, you may find customers surprisingly easy to find – especially if your money-spinning idea has links to space.

You'd be following in a long line of entrepreneurs past, such as when Halley's Comet flew by Earth in 1910. The event caught the attention of opportunists who saw the potential to profit from the unknowns surrounding the comet's appearance. This was nicely fuelled by French astronomer and popular science author Camille Flammarion, who paved the way by stating that Earth would pass through the comet's tail, and that there was a chance that "cyanogen gas would impregnate the atmosphere and possibly snuff out all life on the planet". Just think about that as Earth passes through the dust left by Halley's Comet in its orbit this month, and you're watching for Orionid meteors from the encounter!

While a San Francisco newspaper did remind readers that "most astronomers do not agree with Flammarion," it made little impact on the uncertainty that was left in people's minds – and more importantly to the merchandise that was to be peddled to save us all from oblivion.

Salvation came in the form of anti-comet pills, one such medication promising "an elixir for escaping the wrath of the heavens". Or there was the gas mask that was sold to evade the fumes, although it wasn't specified how long to use it for, which could itself have had long-term drawbacks. As the comet approached, those householders who had not been drawn into the craze stuffed paper around their doorframes in an effort to keep the toxic gas out.

But of all the craziness that ensued to defend oneself against the incoming comet, anti-comet umbrellas were surely the best (an idea taken to a different level decades later, with a meteorite-deflecting helmet). You can imagine how an umbrella could easily deal with all that a massive comet could throw at Earth and its residents. Halley's Comet duly passed by, leaving Earth unscathed, returning again – but with less hysteria attached – in 1986.

Surely today things have moved on, with a more knowledgeable and discerning potential buyer in the marketplace? Perhaps not! Would you like to buy a nice piece of land on the Moon? A quick Google and its yours, courtesy of a 'lunar real estate agent'. Excellent views, especially for stargazing, but a bit sparse on local amenities when you want to buy a pint of milk. This too is just an opportunistic fancy: according to a 1967 agreement, known as the Outer Space Treaty, you cannot buy land on the Moon, so that idea will have to wait. There are many legitimate products that take their names from astronomical bodies, but any that claim to give you X-ray vision, or the ability to read people's minds (I knew you'd say that), do add a pinch of salt!

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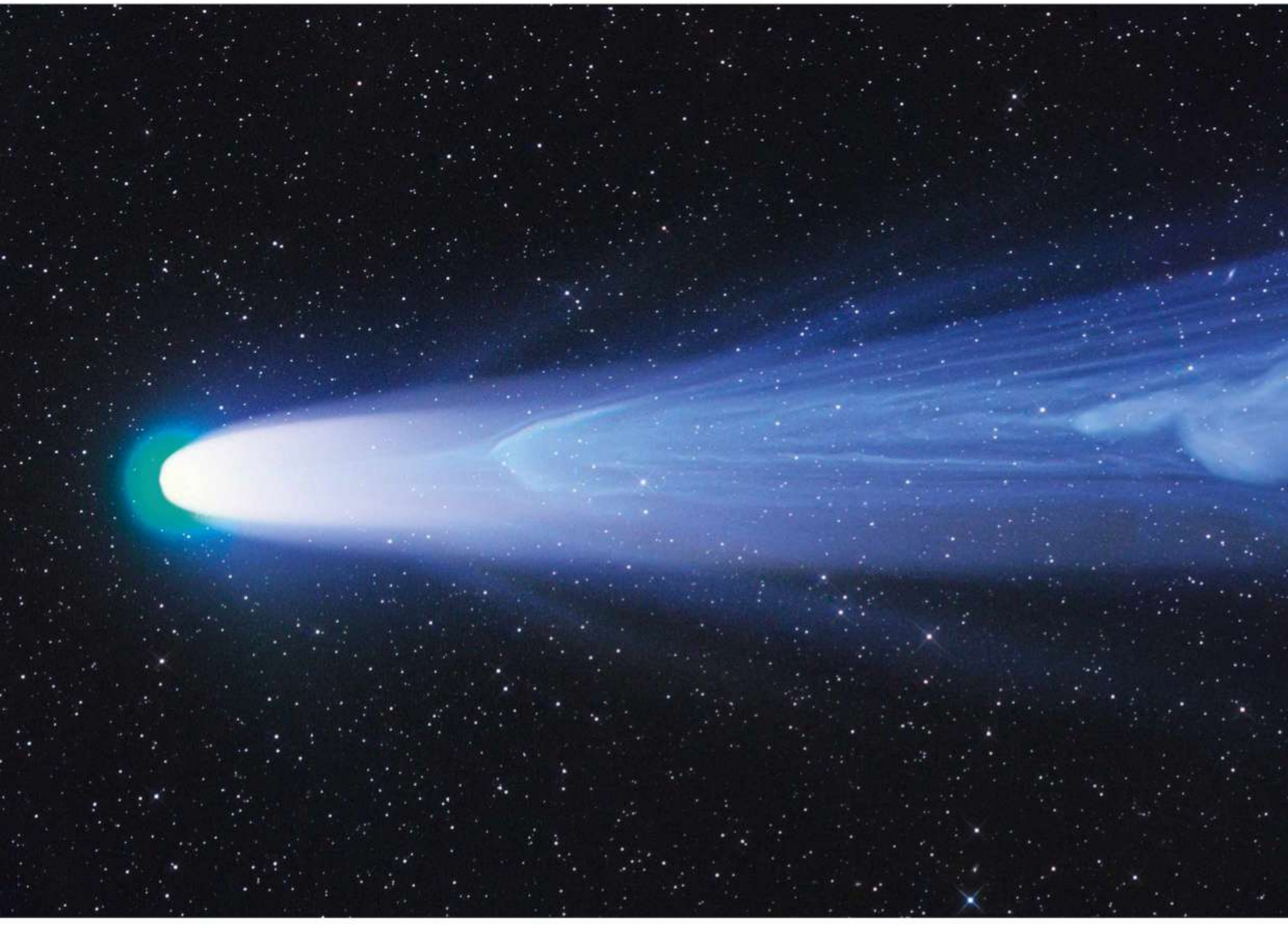
BBC Sky at Night MAGAZINE

Astronomy Photographer of the Year

BBC Sky at Night Magazine is proud to reveal the 2022 winners of the world's biggest astrophotography contest



△ OVERALL WINNER / Planets, Comets & Asteroids

Disconnection Event

Gerald Rhemann

Location: Khomas, Namibia, 25 December 2021

Equipment: ASA 12-inch astrograph, ASA DDM85 mount, ZWO ASI6200MM Pro camera, 1076mm f/3.6, mosaic of two LRGB composite panels, 400-second exposure per panel

Judge's verdict: "Astronomy, myth and art come together beautifully in this shot. It holds great value to scientists, as it elegantly captures a disconnection event. Yet this photograph, which was taken on Christmas Day, seems to tell an otherworldly story too – it could be the Star of Bethlehem, an angel or a fairy soaring through the night sky." **– Imad Ahmed** ▸

Once again, astrophotographers from across the globe have submitted their best work in a bid to win the prestigious title of Astronomy Photographer of the Year 2022. The panel of judges had their work cut out, picking from 3,204 incredible images submitted by 649 entrants from six continents. After lengthy and detailed deliberations, they have selected the best of the best, and we have the pleasure of presenting the winners of the 14th contest here, across all eight main categories. You can also see winners of the competition's special prizes for astrophotography newcomers and for imagers who have processed professionally taken data, as well as the special prize for entrants younger than 16. You can see the winning photos for yourself at the National Maritime Museum in Greenwich, London from 17 September. Visit **www.rmg.co.uk/astrophoto** for details.

MORE ONLINE

A gallery of these and more stunning images from the 2022 competition

FREE 2023 CALENDAR

If you want to see these stunning images throughout next year, pick up the December issue of *BBC Sky at Night Magazine* for our free 2023 calendar. As well as listing all the unmissable astronomical events throughout the year, each month features one of the winners from Astronomy Photography of the Year 2022. It'll be on sale from 17 November 2022.

◁ Aurorae

In the Embrace of the Green Lady

Filip Hrebenda

Location: Hvalnes, Iceland, 10 April 2021

Equipment: Sony ILCE-7RM3A camera, 16mm lens, f/2.8 aperture, ISO 2500 Sky: 5-second exposure, foreground: 20-second exposure

Judge's verdict: "I love this – it sums up aurorae for me: the green 'swoosh' reflected in the icy lake, the clarity of the edges of the ice blocks and the looming shadow of the mountain." **– Sheila Kanani**

Galaxies ▷

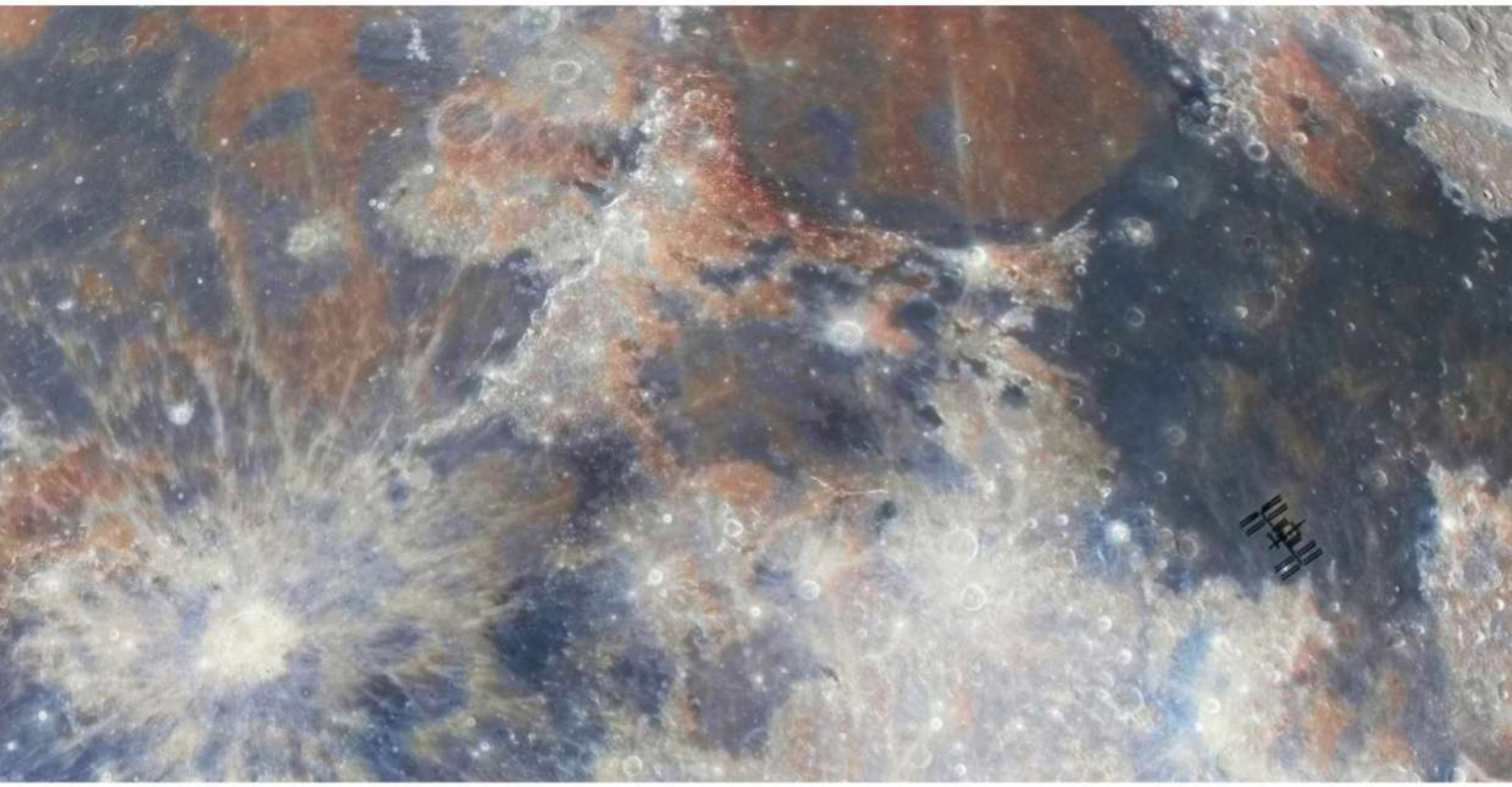
Majestic Sombrero Galaxy

Utkarsh Mishra, Michael Petrasko, Muir Evenden

Location: New Mexico, USA, 5 May 2021

Equipment: ATEO 16-inch f/3.7 Dreamscope Newtonian astrograph, Paramount ME II mount, Baader LRGB filter, FLI Proline 16803 CCD camera, 1,558mm f/3.7, 56x 300 seconds

Judge's verdict: "The Sombrero is a well-documented galaxy, yet astrophotographers still find ways to tease more majesty from it. To see the misty remnants of previous collisions surrounding the galaxy, itself floating alone in the void, is just exquisite." **– Steve Marsh**



△ People and Space

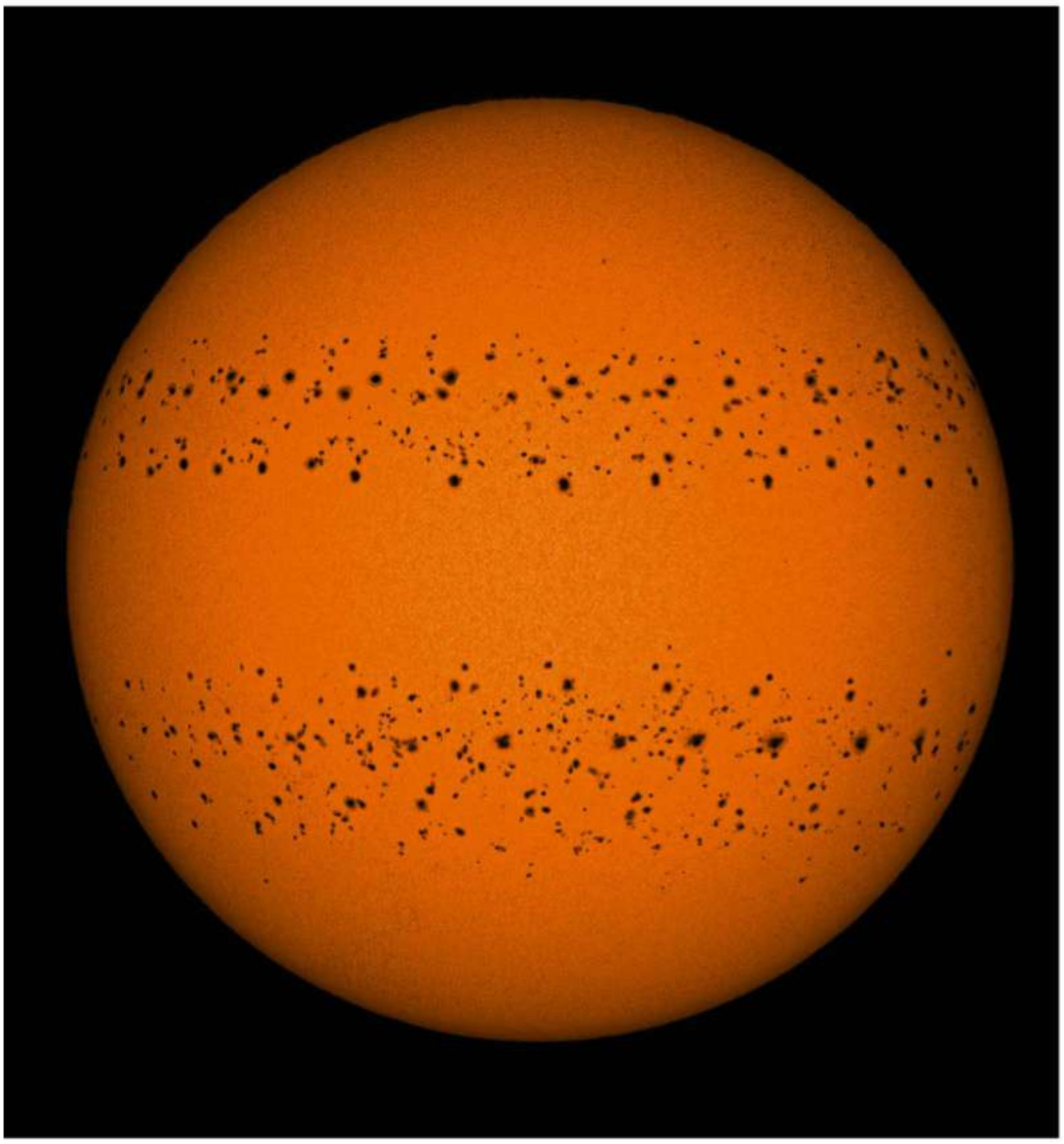
The International Space Station transiting Tranquility Base

Andrew McCarthy

Location: Arizona, USA, 19 January 2022

Equipment: Celestron C11 and Explore Scientific AR127 telescopes, iOptron CEM70 mount, UV/IR Cut filter, ZWO ASI174MM and Sony A7 II cameras, 2,800mm f/10, 0.3-millisecond exposure

Judge's verdict: "The symbol of man, the tiny silhouette of the ISS, is dwarfed by the vast and detailed lunar surface, coloured by mineral deposits. It shows us just how fragile we are." **– László Francsics** ▸



◁ Our Sun

A Year in the Sun

Soumyadeep Mukherjee

Location: West Bengal, India, 31 December 2021

Equipment: Nikon D5600 camera, Sigma 150–600c lens, Thousand Oaks filter (White-Light), 600mm lens, f/6.3 aperture, ISO 100, 365 individual exposures (1/80-second to 1/500-second)

Judge's verdict: "The commitment and diligence (not to mention luck) needed to image the Sun every day for a year is a feat within itself. But, more than just a matter of hard work, this photographer has achieved a fascinating and unique look at the progression of sunspot bands across its disc." **– Steve Marsh**

◁ The Sir Patrick Moore Prize for Best Newcomer

This special prize is awarded to an astrophotographer who started the hobby in the last two years

The Milky Way Bridge Across Big Snowy Mountains

Lun Deng

Location: Sichuan, China, 21 February 2021

Equipment: Nikon D810 camera, 35mm lens, f/1.6 aperture, ISO 2000, multiple 30-second exposures

Judge's verdict: "The icy, ragged mountaintop is contrasted beautifully with the Milky Way, the lighter pink and indigo hues of which offer us a mesmerising, warm glow. I also have to commend the photographer's dedication – standing in the snow in freezing conditions – to capture this picture!" **– Imad Ahmed**

▽ Skyscapes

Stabbing into the Stars

Zihui Hu

Location: Tibet, China, 24 December 2021

Equipment: Sony ILCE-7R3 camera, Tamron 150–500mm lens at 150mm, f/5.6 aperture, 75x 30-second exposures

Judge's verdict: "I love the juxtaposition of the star trails against the clear peak of the mountain. The motion of the clouds adds to the drama." **– Sheila Kanani** ▸

△ Stars and Nebulae

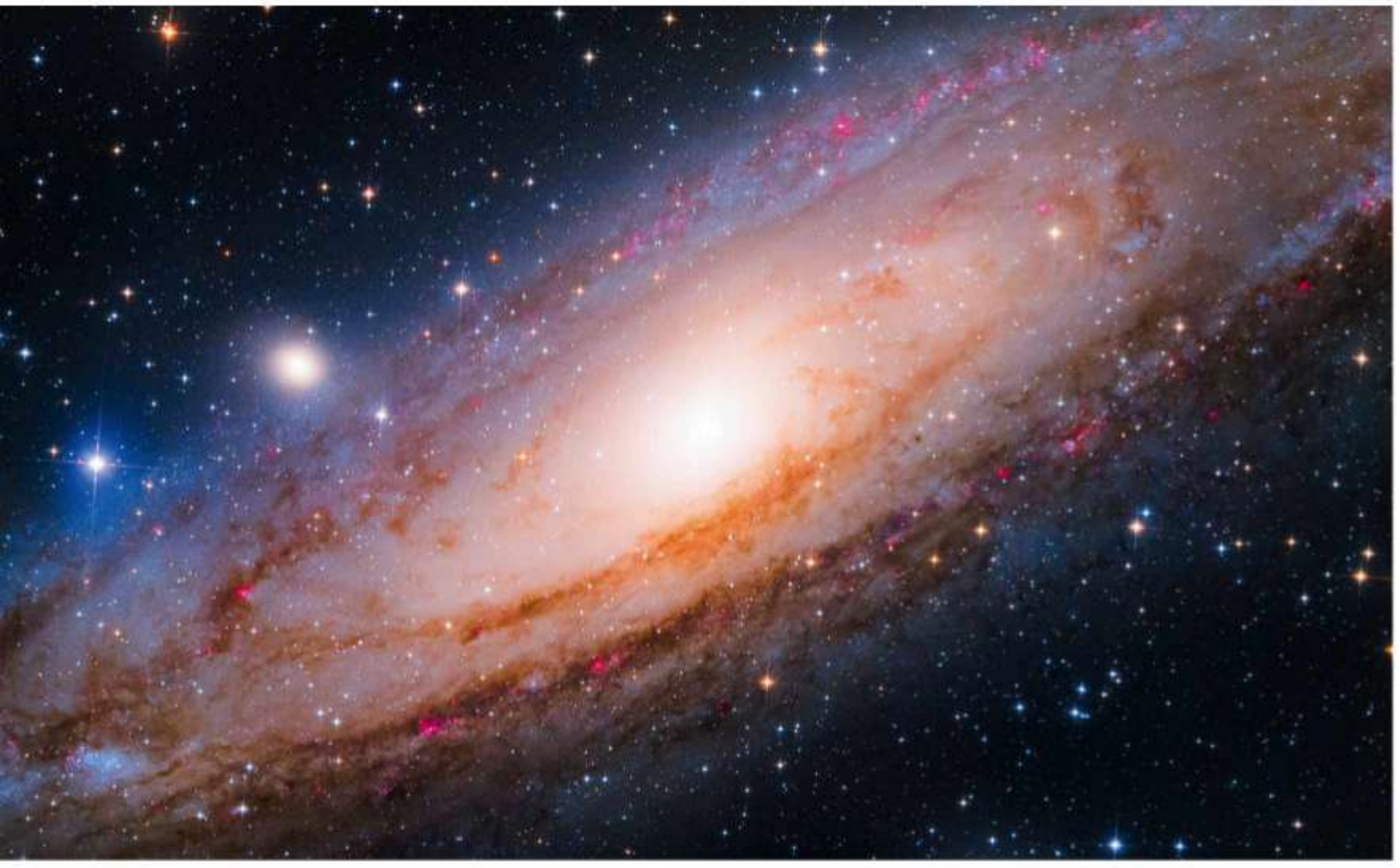
The Eye of God

Weitang Liang

Location: Coquimbo region, Chile, 8 August 2021

Equipment: ASA N20 Newtonian telescope, ASA DDM85 mount, FLI Proline 16803 camera, 500mm f/3.8, 22.5 hours total exposure

Judge's verdict: "The colours in this photograph make for a stunning composition – from the fiery red to the defiant, moody blue at the centre of the 'eye'. It's easy to see how the ancients used to stargaze into the heavens and imagine that the cosmos was looking back, keeping a watchful eye over us." **– Imad Ahmed**



△ Young Astronomy Photographer of the Year

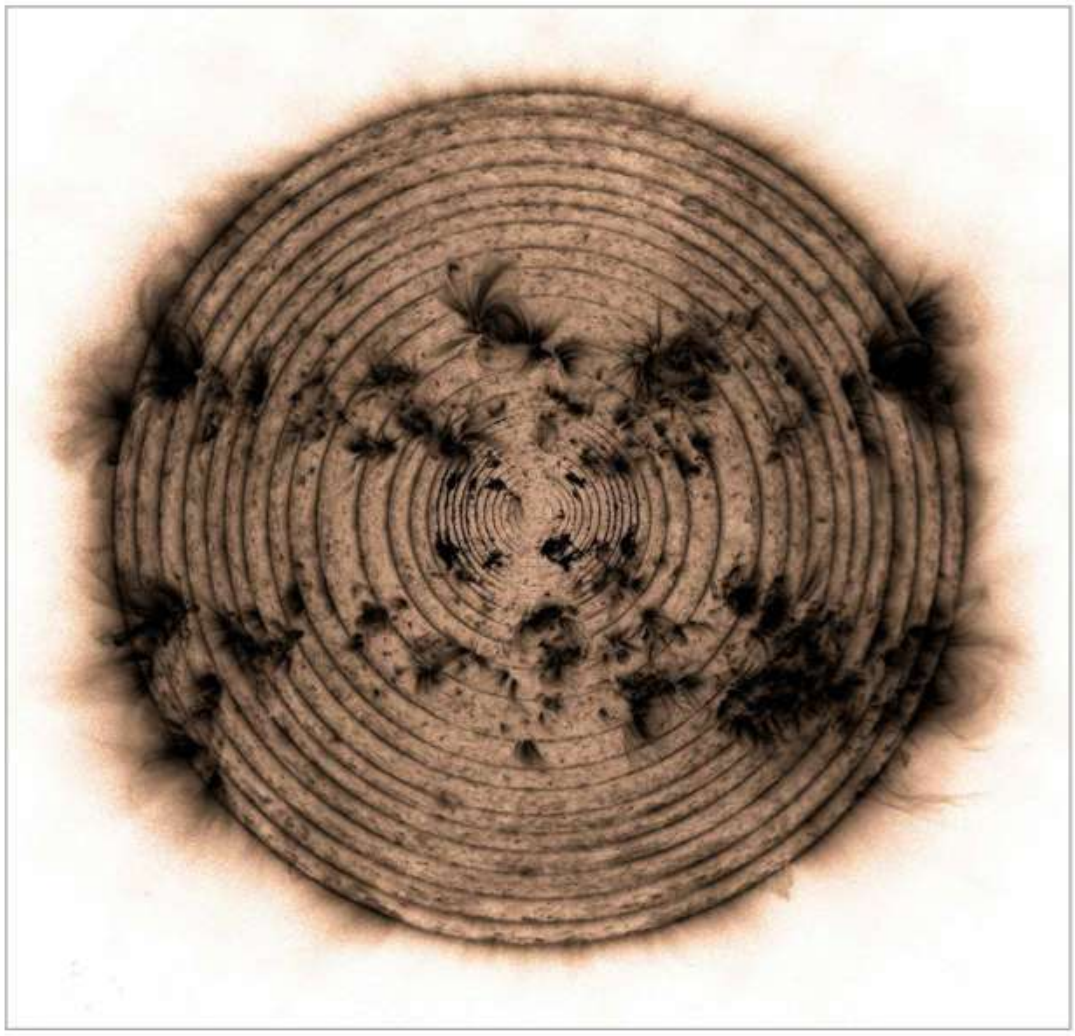
Andromeda Galaxy, The Neighbour

Yang Hanwen and Zhou Zezhen, aged 14

Location: Yunnan Province, China, 7 October 2021

Equipment: Sky-Watcher 150/750P Newtonian telescope, iOptron CEM70 mount, Antlia LRGB, HYO H-alpha filter, ZWO ASI294MM Pro camera, 750mm f/5, 17 hours total exposure

Judge's verdict: "From the dark dust lanes to the HII regions, these young photographers have expertly bought out the galaxy's stunning details to produce a vibrant image. One of my favourite pictures from the competition!" **– Melissa Brobby**



◁ The Annie Maunder Prize for Digital Innovation

Entrants were invited to put a unique spin on data taken by professional observatories

Solar Tree

Pauline Woolley

Location: UK

Data source: Solar Dynamics Observatory

Equipment: Original images from the AIA 0131 Angstrom channel of the Solar Dynamics Observatory (SDO), 1 January 2020 to 1 February 2022

Judge's verdict: "Dendrochronology – the scientific method of calculating dates based on tree rings – is used by art historians and conservators to date wood panel paintings, but here the technology has been utilised to create an unusual and beautiful composition. This is an innovative photograph that immediately astonished all the judges." **– Hannah Lyons**

Our Moon ▷

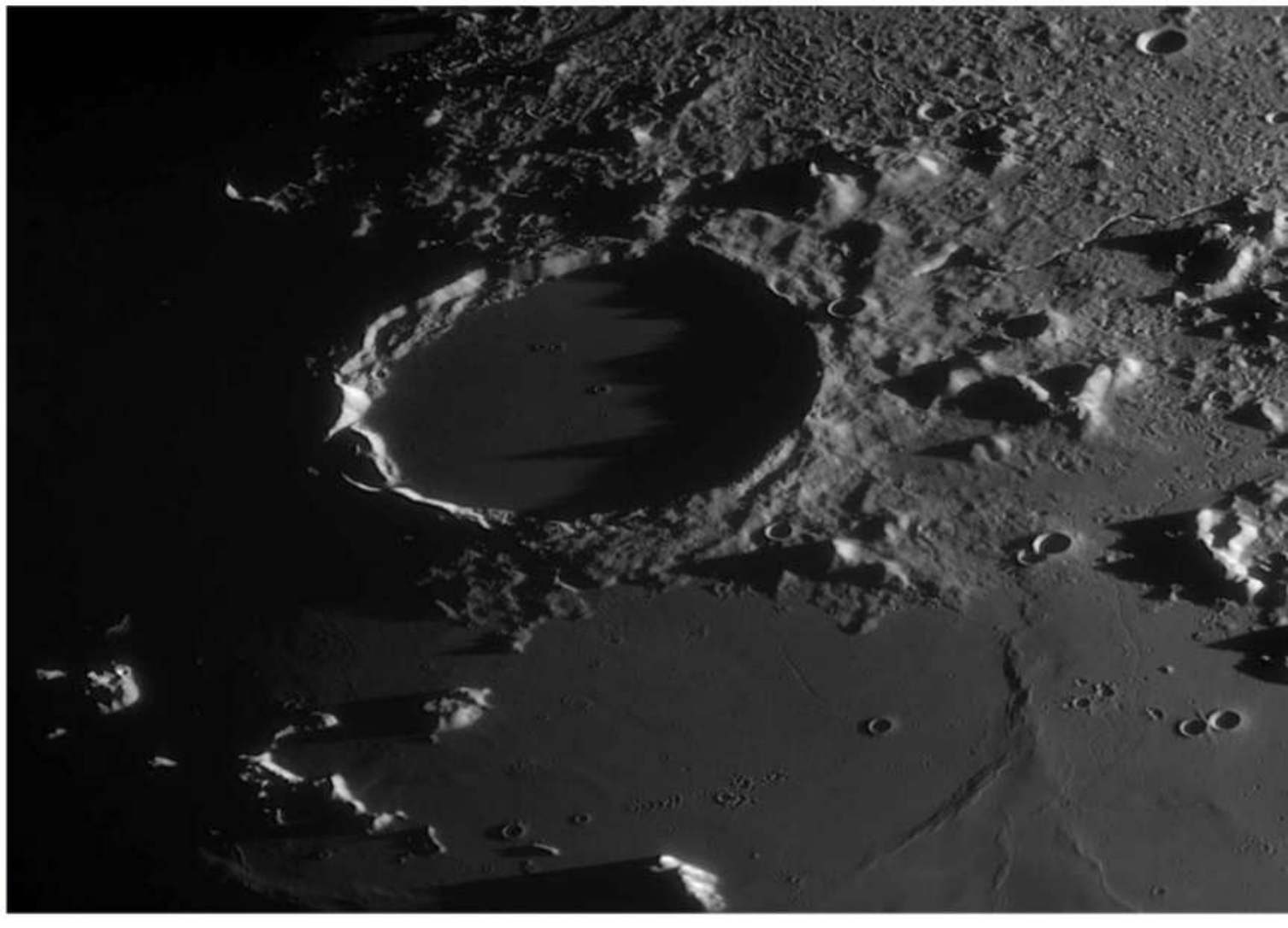
Shadow Profile of Plato's East Rim

Martin Lewis

Location: Hertfordshire, UK, 20 April 2021

Equipment: Home-built 444mm Dobsonian Newtonian reflector telescope, home-built equatorial tracking platform mount, Astronomik 642nm IR filter lens, ZWO ASI174MM camera, 12.8m f/29, multiple 29-millisecond exposures

Judge's verdict: "This close-up of the Plato crater has become one of my favourite photographs of the Moon. This image of the east rim being hit by the Sun's rays is wondrously unique and proves that, no matter how often we look at the Moon, it always has many more wonderful sights for us to observe." **– Melissa Brobby**



THE JUDGES

Imad Ahmed: Director of the New Crescent Society, celebrating Islam's rich astronomy heritage.

Yuri Beletsky: Professional astronomer and nightscape photographer based in Chile.

Ed Bloomer: Public Astronomy Manager at Royal Museums Greenwich.

Melissa Brobby: Science communicator and Social Media Officer for the Institute of Physics.

László Francsics: Architect and chair of the Hungarian Astrophotographers' Association.

Shelia Kanani: Planetary scientist and Education, Outreach and Diversity Officer at the Royal Astronomical Society.

Hannah Lyons: Assistant Curator of Art at the Royal Museums Greenwich.

Steve Marsh: Art Editor of *BBC Sky at Night Magazine*.

Alan Sparrow: Chair of the UK Picture Editors' Guild and Director of the UK Pictures Editors' Guild Awards.

ARTEMIS BEGINS

As Artemis I takes the first step in NASA's plan to return humans to the Moon, **Shaoni Bhattacharya** talks to the people behind the wider series of missions

This year heralds the first crucial stage in NASA's ambitious plans to put 'boots back on the Moon', as Artemis I gets ready for launch.

Artemis I is an uncrewed flight test of two new space systems: the world's most powerful rocket – the Space Launch System – and the Orion crew spacecraft. It will travel to the Moon, skimming 100km above its surface before entering a retrograde orbit that takes it 70,000km beyond the lunar far side and returns to Earth 4–6 weeks later. Though it will have no human crew this time around, it will deploy multiple CubeSats to perform a range of science experiments.

Should all go well, Artemis II will take a four-person crew to lunar orbit and back no earlier than 2024. Finally, Artemis III aims to send astronauts to the lunar surface in 2025, with NASA vowing to put the first woman on the Moon and the first person of colour. Beyond this are plans for building the Lunar Gateway, a staging post in lunar orbit that will enable humans to stay at the Moon for months at a time. To learn more about the programme, we spoke to key figures across the Artemis project.

Primed for flight, Artemis I's Space Launch System rocket and Orion crew module... with their lunar target in sight

A prototype Orion module in splashdown testing. The new generation of spacecraft can carry up to six astronauts

Orion's first flight

The Orion module will house future crews bound for the Moon and for deep space beyond. Its manager **Debbie Korth** reveals how Artemis I will put the new spacecraft through its paces

How will Artemis I test the Orion crew and service module before it carries humans in Artemis II?
There are several big systems that we want to check out. The Orion capsule has a 4.9m diameter heat shield – we need to see how that performs. Orion will come back from the Moon at about 40,000km/h and the heat shield will get to about 2,750°C.

Another objective is our entry, descent and landing back on Earth. At around 480km/h, the 11 parachutes start deploying. When the capsule hits the water, it's got to be at 32km/h or less. That whole sequence is a very orchestrated set of events we'll be testing.

Finally, there's the Crew Module Uprighting System, which deploys a series of bags and balloons [to keep Orion floating] until the recovery crew picks it up.

What are the major challenges with building Orion compared with past vehicles?
One of the biggest ones is the overall mass. We're trying to build a spacecraft that's robust and can support four people for 21 days. But it's also got to be light enough that you can actually fly it. ▸

A series of parachutes will slow the module to 32km/h before it hits the Pacific

NASA/CORY HUSTON, NASA X 2

Orion's first test flight will last longer and travel further than any Moon mission that has gone before

1. SLS and Orion launch from Kennedy Space Center; boosters and core stage jettisoned.

2. Orion and the Interim Cryogenic Propulsion Stage (ICPS) reach Earth orbit.

3. A 20-minute trans-lunar injection burn propels Orion towards the Moon.

4. Orion separates from ICPS. ICPS takes dotted grey line to a disposal orbit around the Sun.

5. First lunar fly-by, 100km from the surface.

6. Orion enters a distant retrograde orbit (DRO) around the Moon.

7. At its furthest point, Orion is 64,000km from the Moon's surface.

8. Orion leaves DRO and begins return to Earth.

9. Second fly-by of the lunar surface; thrusters fire to begin Orion's return coast to Earth.

10. Orion's crew module separates from the service module.

11. Atmospheric entry at 39,500km/h.

12. Orion's splashdown in the Pacific Ocean, with recovery by the US Navy.

A. B. C. ICPS deploys its 10 CubeSats at the points shown.

MISSION DURATIONS
Total: 26–42 days. Outbound transit: 8–14 days. DRO stay: 6–19 days. Return transit: 9–19 days.

▲ **Above left: the Launch Abort System, designed to carry the crew to safety in the event of an emergency during launch or ascent**

Above right: the assembled crew and service module stack being readied for testing in 2019

NASA, NASA/TONY GRAY AND KEVIN O'CONNELL, NASA/RAD SINYAK, NASA/BILL INGALLS X 17, NASA, NASA/JOEL KOWSKY)

► The other is distance. The Space Shuttle and the International Space Station went to low-Earth orbit a couple of hundred kilometres up – we're going 385,000km to the Moon. If you have a problem, coming home can take up to three days, so Orion has many redundant [back-up] systems. Our Launch Abort System on top of the Orion capsule is also quite unique. If there's a problem during the launch, it can pull the spacecraft off immediately. There's a lot more safety-critical redundancy built into this vehicle than in the past.

When Artemis I launches, what are the key moments when you'll be holding your breath?
For me, I think the first 'Ahhh' moment will be when the Launch Abort System separates from the spacecraft. That means we've achieved a safe orbit, we no longer need to have the ability to pull the crew module off.

Getting into orbit around the Moon will be another, 'Wow, we made it!' moment. This spacecraft is going further than any human-rated spacecraft ever. We're going not just to the Moon 385,000km away, but another 64,000km beyond that. In pictures from the spacecraft you'll be able to see the Moon and Earth – I think it's going to be beautiful.

The third thing will be the landing back on Earth. That's when we are really going to prove our systems.

If all goes to plan with Artemis I, what are your dreams for the programme?
To me, Artemis I and II are proving out flights. What I'm most looking ahead to is Artemis III, when we have boots on the Moon again. That to me is really exciting. I have three kids; two are daughters and one's in high school. When I talk to her about putting a woman on the Moon she says, "What! A woman never went?". That's what I'm really looking forward to.

How to train an astronaut

A lunar mission is a mammoth undertaking, demanding a lot from its crew. **Jacki Mahaffey**, lead chief training officer for Artemis II, tells us how the astronauts will prepare

▲ The Artemis astronauts, clockwise from top left: Joseph Acaba, Kayla Barron, Raja Chari, Matthew Dominick, Victor Glover, Warren Hoburg, Jonny Kim, Christina H Koch, Kjell Lindgren, Stephanie Wilson, Jessica Watkins, Scott Tingle, Frank Rubio, Kate Rubins, Jasmin Moghbeli, Jessica Meir, Anne McClain and Nicole A Mann. The mission plans to put the first woman and person of colour on the Moon

Eighteen astronauts have been selected for NASA's 'Artemis Team' to support missions to the Moon. Following Artemis I, four NASA astronauts will be selected by the end of this year to fly to lunar orbit with Artemis II.

Since the training for this mission is brand new, Jacki Mahaffey from Johnson Space Center in Houston is leading a team of instructors not only to conduct astronaut training, but also to draw up the Artemis training programme.

"We start with training for the Orion capsule and launching on the Space Launch System (SLS) because the Artemis II mission will be a figure-8 around the Moon," she said. "Then we'll continue to grow as we add the [Lunar] Lander and Gateway and learn how to use suits to do moonwalks and all sorts of things."

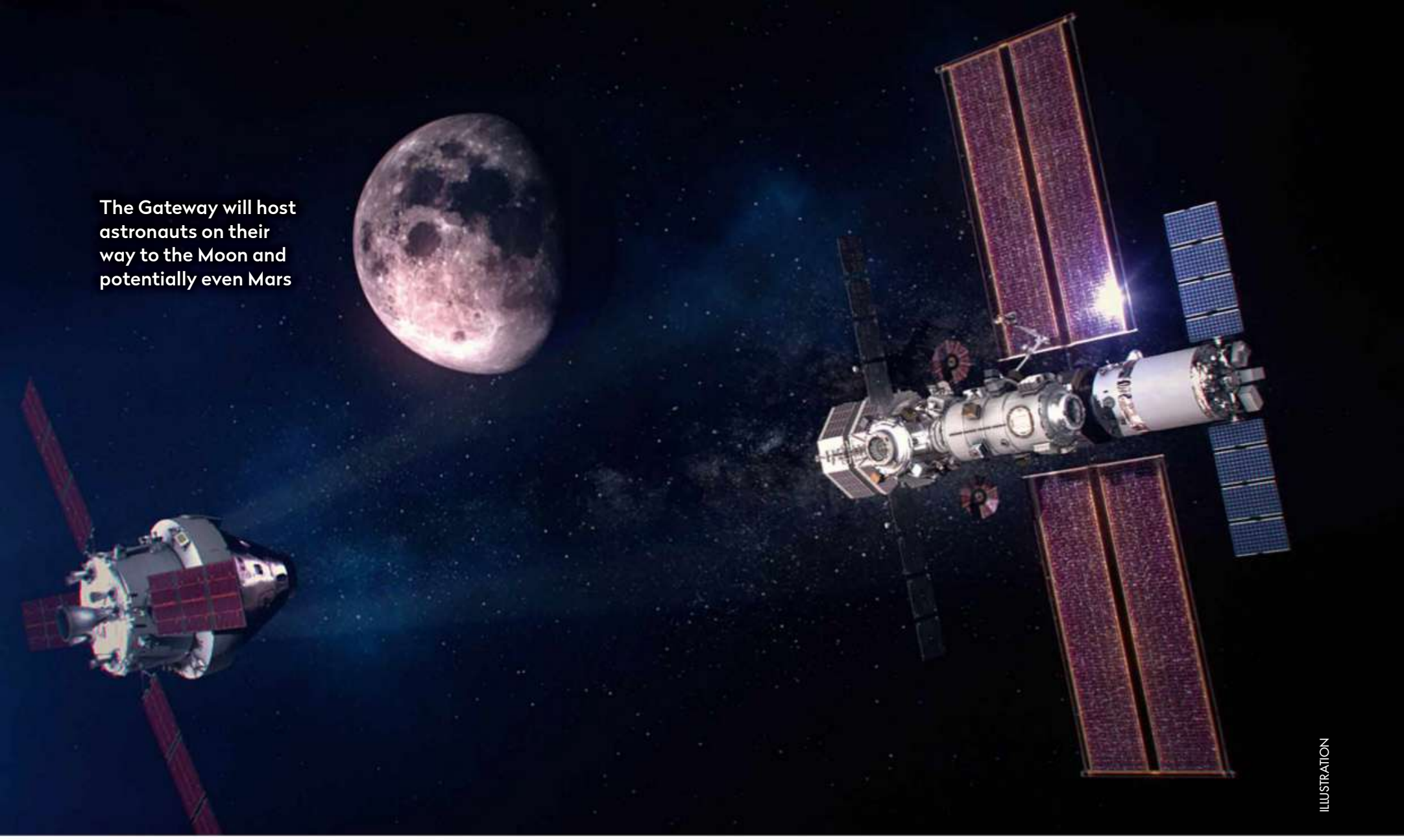
During Apollo crew training in the 1960s, one of the main tasks was learning to navigate the dizzying array of switches and systems in the spacecraft, but a lot has changed in the last 50 years.

"One of the big differences between the earlier missions and what we have now is much more computer power and automation capability," says Mahaffey. "There's a lot fewer switches and circuit breakers in the Orion capsule than you would have seen on the Shuttle or in an Apollo capsule.

▼ What the next moonwalker will wear. Spacesuit engineer Kristine Davis in the new 'extravehicular mobility unit'

"But it leaves an interesting puzzle. The reason that we're flying humans is because we have this unique capability to synthesise the unexpected. But maybe we didn't anticipate something when we built the computer. Can the crew understand what the computer has been trying to do, and then insert themselves into that process to achieve mission success? A big part of our training is to give them enough background on what the vehicle is doing."

Looking forward to the Moon landing of Artemis III, the lunar environment hasn't changed at all since Apollo – it's still dusty with one-sixth the gravity of Earth. The landing will happen near the southern pole and the low Sun will cast many more shadows than the more equatorial Apollo landings. One area that has improved, however, is the space suits, which are much better fitting, with more mobility, meaning astronauts should be able to bounce-walk across the surface with ease. ▸



The Gateway will host astronauts on their way to the Moon and potentially even Mars

ILLUSTRATION

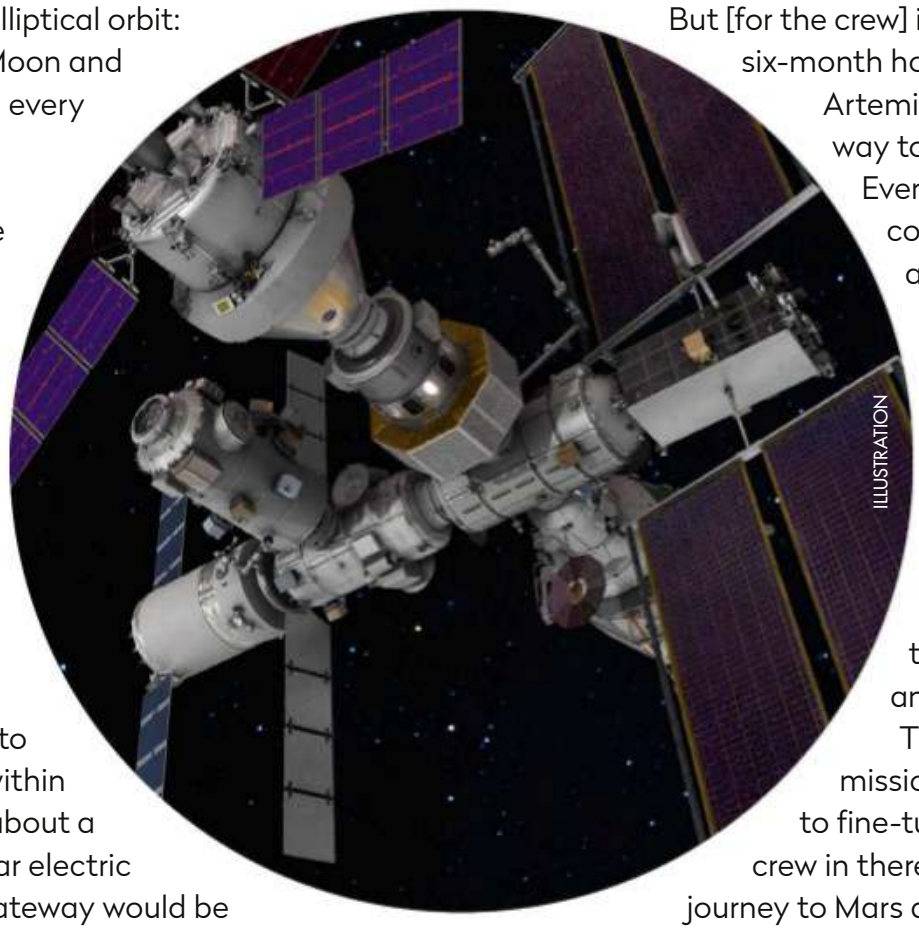
Gateway to the Moon

Dan Hartman, programme manager for NASA's Lunar Gateway, tells us about the ambitious project to construct a permanent space station in orbit around the Moon

The Lunar Gateway will sit in an elliptical orbit: we'll get within 10,000km of the Moon and then out to about 70,000km. And every six-and-a-half days we'll make a complete revolution.

It'll be maybe one-eighth of the size of the ISS and is going to be human-tended, nominally for 30 days but we can go to 60 or 90 days. Even though it's not permanently crewed, we are going to run research on the Lunar Gateway 24/7, 365 days a year. The first two elements of the Gateway – the PPE (Power Propulsion Element) and HALO (Habitation and Logistics Outpost) – are planned to fly up on a Falcon Heavy rocket within the next few years, and will take about a year to get to the Moon using solar electric power propulsion. So the initial Gateway would be in place and ready to accommodate the first crew of Artemis IV in late 2026.

It will have a lot of similarities with the International Space Station: a cupola, so the crew can see out; exercise devices and sleep stations.



ILLUSTRATION

▲ **Like the ISS, the Gateway will be habitable, but it won't have permanent crew**

But [for the crew] it's more of a camping trip than a six-month hotel stay like the ISS.

Artemis III is our fastest, least complex way to get a crew to the surface.

Every mission after that is going to come to the Gateway. It will be an aggregation point. Ahead of a mission we'll launch the supplies, research tools, EVA suits, all those kinds of things, as well as the human landing system.

Finally, the four crew will come on an Orion. [Once on board] two crew get in a lander and go to the surface of the Moon, while two crew stay on the Gateway and do research or maintenance.

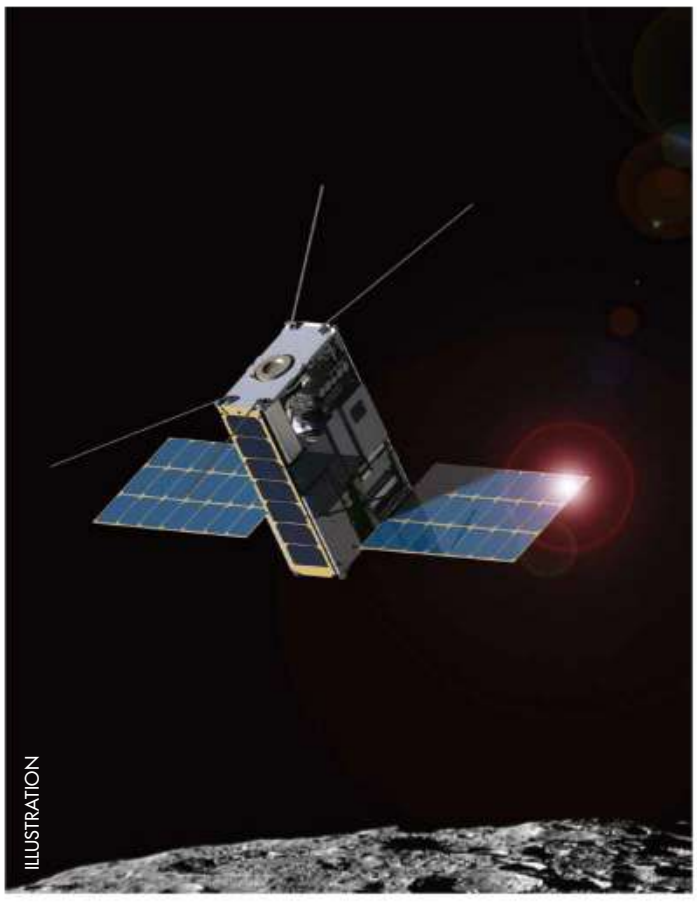
Thinking forward to potential Mars missions, the Gateway offers a place to fine-tune modules before you put the crew in there to head off on an 18-month journey to Mars and back.

We're building the Gateway to last 15 years. Just like the ISS, which extended its life based on how well it's performing, I fully envision us doing the same on Gateway. It wouldn't surprise me if we're good for 20 or 25 years."

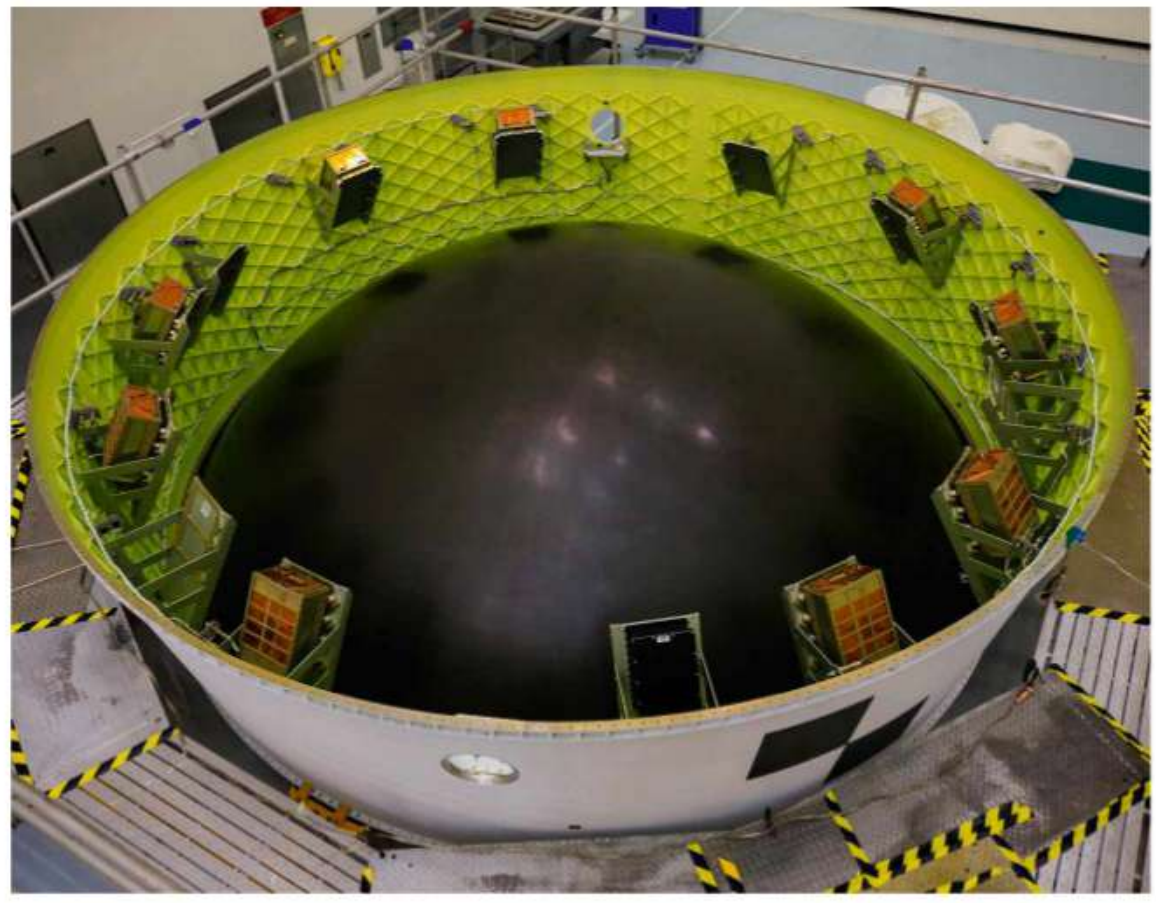
NASA/ALBERTO BERTOLIN, NASA X 3

Small spacecraft, big science

Ten shoebox-sized CubeSats are hitching a ride on top of the Artemis I mission. We meet **Andres Martinez**, programme executive for NASA's Small Spacecrafts, to find out more



ILLUSTRATION



▲ Above left: a secondary payload to Artemis I, Lunar IceCube will map water on the Moon

Above right: CubeSats being installed inside the SLS's Orion Stage Adapter in 2021

How many CubeSats are on board Artemis I?
There are 10 CubeSats installed alongside Artemis I. Seven of them are sponsored by NASA; four are under my responsibility. We also have three international CubeSats aboard. When you see the size of these CubeSats, and look into the incredible science that we're going to be conducting, your first reaction is 'no way!', because they're the size of a shoebox.

What sort of science will your four CubeSats be conducting?
The first is called Lunar IceCube and is led by Morehead State University in eastern Kentucky, with 100 university students participating. Lunar IceCube will orbit the Moon for six months and has an incredible infrared spectrometer. It will document where water is on the Moon and its daily movement.

The second one, LunIR, is led by Lockheed Martin. It doesn't have any propulsion, but will travel on a ballistic trajectory straight to the Moon. Over the 72 minutes that it goes by the Moon it's going to take some incredible high-resolution images with a very sophisticated infrared instrument.

Shaoni Bhattacharya is a science writer and editor, as well as a short fiction author

The third is the Near-Earth Asteroid Scout, led by Marshall Space Flight Center. It will rendezvous with an asteroid, take images and send those back to us. It will use a 80m^2 solar sail – the size of a bus – as its main propulsion system. The target asteroid is about the size of a Volkswagen.

The fourth mission is BioSentinel, led by Ames, which will send live biology further into space than ever before, namely yeast. We are going to put BioSentinel in a heliocentric orbit, trailing behind Earth. As we expect solar events to take place, it will go through very harmful radiation and we're going to document the effects on live organisms.

Do you have a favourite CubeSat?
I'm very fond of Lunar IceCube because I saw many kids grow up during the project. A couple were a little cocky, but I could see fear in some of them – especially when I walked into the room in a suit with a NASA pin. The first thing I would tell them was "I'm one of you. NASA is on your team." What makes me super-happy is that a lot of these kids have now graduated and come to work here at NASA.

ROYAL MUSEUMS GREENWICH

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

OCTOBER 2022

A BITE FROM THE SUN

Catch the partial solar eclipse on 25 October, as the Moon clips the Sun's disc

PETE LAWRENCE

NEPTUNE AND JUPITER

Track the planetary pair together near the Circlet

SHOWER TIME

Watch Orionid meteors unspoilt by moonlight

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- Bright Mercury chases an earthshining thin Moon
- Take our low-altitude spotting challenge
- Mars reverses direction

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

OCTOBER HIGHLIGHTS

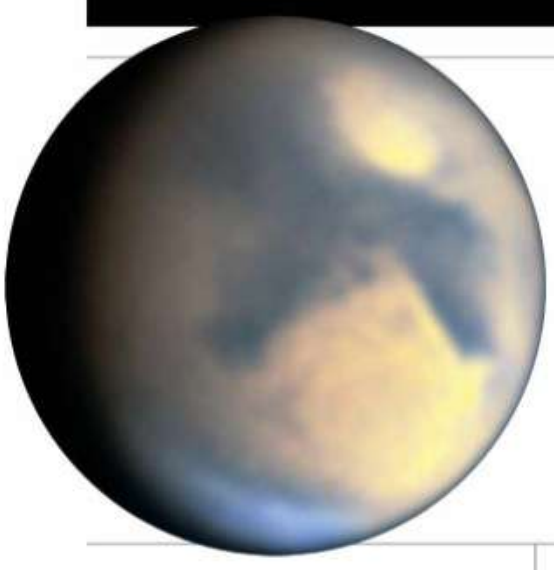
Your guide to the night sky this month

◀ Sunday
2 The clair-obscur effects known as the lunar X and V are visible early evening and reach their peak just before 19:00 BST (18:00 UT) .

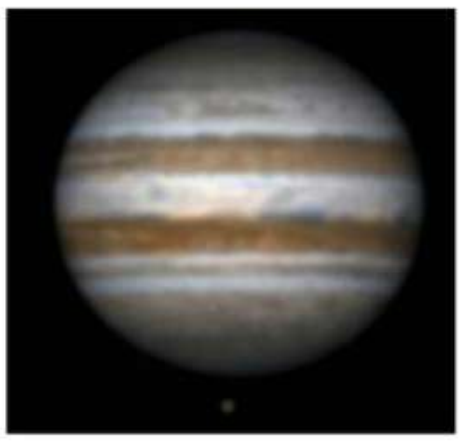
Wednesday
5 This evening's 80%-lit waxing gibbous Moon sits 5° to the southeast of mag. +0.6 Saturn.

Saturday ▶
8 Mercury reaches greatest western elongation, 18° from the Sun in the morning sky.

This evening the almost full 98%-lit waxing gibbous Moon sits 2.7° below mag. –2.8 Jupiter.



◀ Saturday
15 This morning's 73%-lit Moon lies 3.2° to the north of mag. –0.9 Mars.



◀ Sunday
16 Catch the moon Ganymede being occulted by Jupiter at 01:03 BST (00:03 UT).

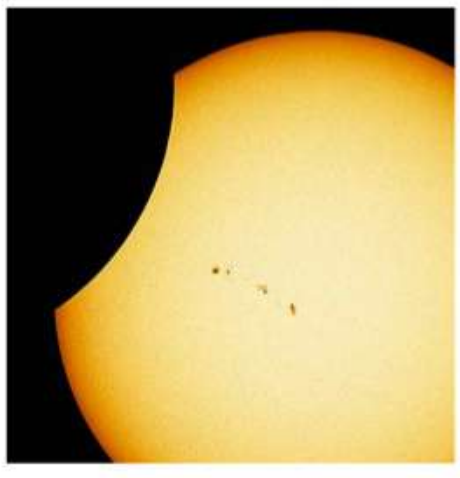
Later, just after sunset, catch the outer Galilean moon Callisto close to the Giant Planet's northern limb.

Tuesday
18 Mag. –0.9 Mercury lies 0.8° from the binary star Porrima (Gamma (γ) Virginis), the pairing visible in the early morning sky after 06:30 BST (05:30 UT).

Wednesday
19 With a telescope, just after sunset see Europa, its shadow and Ganymede's shadow transit Jupiter. Ganymede itself appears off the southwest limb. Europa exits the transit at 19:40 BST (18:40 UT) and Ganymede's shadow at 20:10 BST (19:10 UT).

Friday ▶
21 The Orionid meteor shower is predicted to reach its peak around 19:00 BST (18:00 UT), meaning tonight and into tomorrow morning will be the best viewing window. Turn to page 47 for more information.

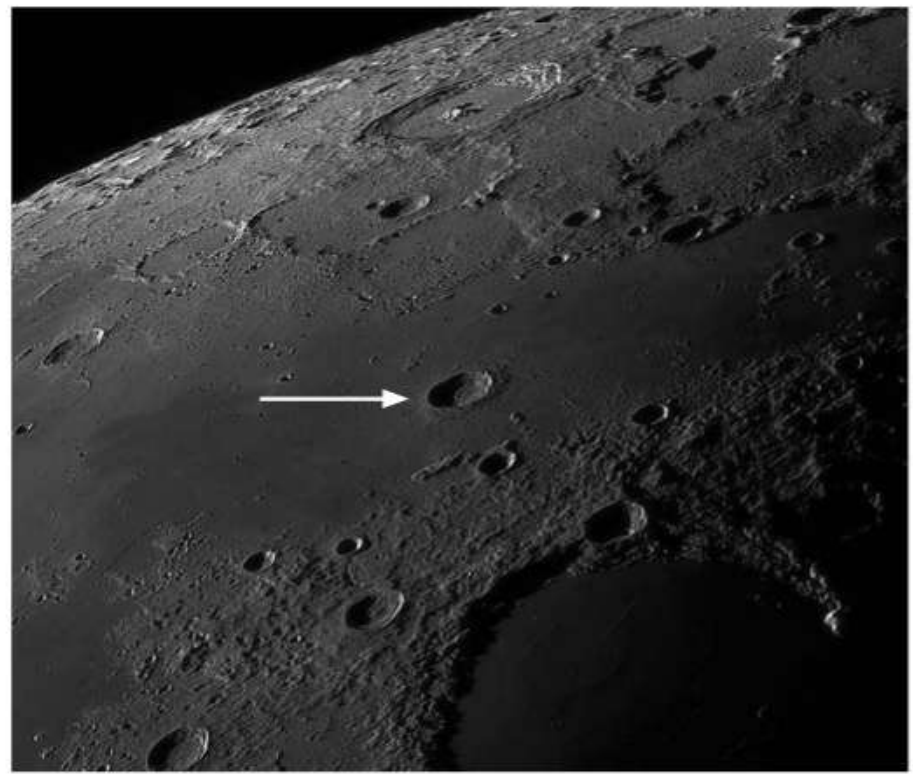
Monday
24 This morning sees an excellent opportunity to spot a very thin waning crescent Moon. Look low above the east-southeast horizon from 07:00 BST (06:00 UT) for mag. –1.0 Mercury with a 2%-lit Moon 4.1° above it. Turn to page 47 for details.



◀ Tuesday
25 A partial solar eclipse can be seen from the UK between 10:00 BST (09:00 UT) and 12:00 BST (11:00 UT). The eclipse is greater towards the northeast of the UK, with maximum magnitudes of 40% coverage from Shetland. See page 46 for more details.

Wednesday
26 It's a Galilean moon jackpot, with transits by Ganymede at 18:15 BST (17:15 UT), Europa at 19:25 BST (18:25 UT), Io's shadow from 20:53 BST (19:53 UT) and Ganymede's from 21:18 BST (20:18 UT). Io is occulted at 20:03 BST (19:03 UT).

PETE LAWRENCE X 9



Thursday ▶

6 Your first good opportunity to spy our Moonwatch target (see page 52), the 40km crater Harpalus found north of the Bay of Rainbows, occurs this evening. Your next chances will be on the mornings of 20 and 21 October.

◀ Sunday

9 There's a chance to see Ganymede emerge from the eclipse of Jupiter's shadow this morning from 01:54 BST (00:54 UT). The moon's disc takes around 10 minutes to fully come out from the Jovian shade, to the east of the planet.

Wednesday

12 As dawn approaches, the 94%-lit waning gibbous Moon can be seen approaching Uranus, lying 1.7° west of the planet at 05:00 BST (04:00 UT). Uranus appears 5 arcseconds from the Moon's southern limb at 08:33 BST (07:33 UT).

Monday ▶

17 Mag. –0.4 Mars lies 1.2° north of M1, the Crab Nebula this evening. A famous supernova remnant, the Crab is considerably dimmer than the planet at mag. +8.4.

Saturday

22 Venus will pass 1.1° to the north of the centre of the Sun's disc today as it reaches superior conjunction, marking its transition from the morning into the evening sky.

Sunday

30 UK Daylight Savings Time ends at 02:00 BST this morning, with clocks going back to 01:00 UT.

Mars reverses direction in the sky and is now showing retrograde motion against the background stars.

Family stargazing

A safe way to observe the partial solar eclipse on the morning of 25 October (see page 46) is to use a piece of card with a 1–2mm circular hole in it. Important: don't look directly at the Sun. Instead, with your back to the Sun, hold the card up so sunlight can pass through the hole onto a piece of white paper. Look at the bright dot in the centre of the dark shadow on the white paper and you'll see it takes on the shape of the partially eclipsed Sun. Place the pinhole card a metre from the projection screen and move it back and forth until you get the sharpest image. **bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

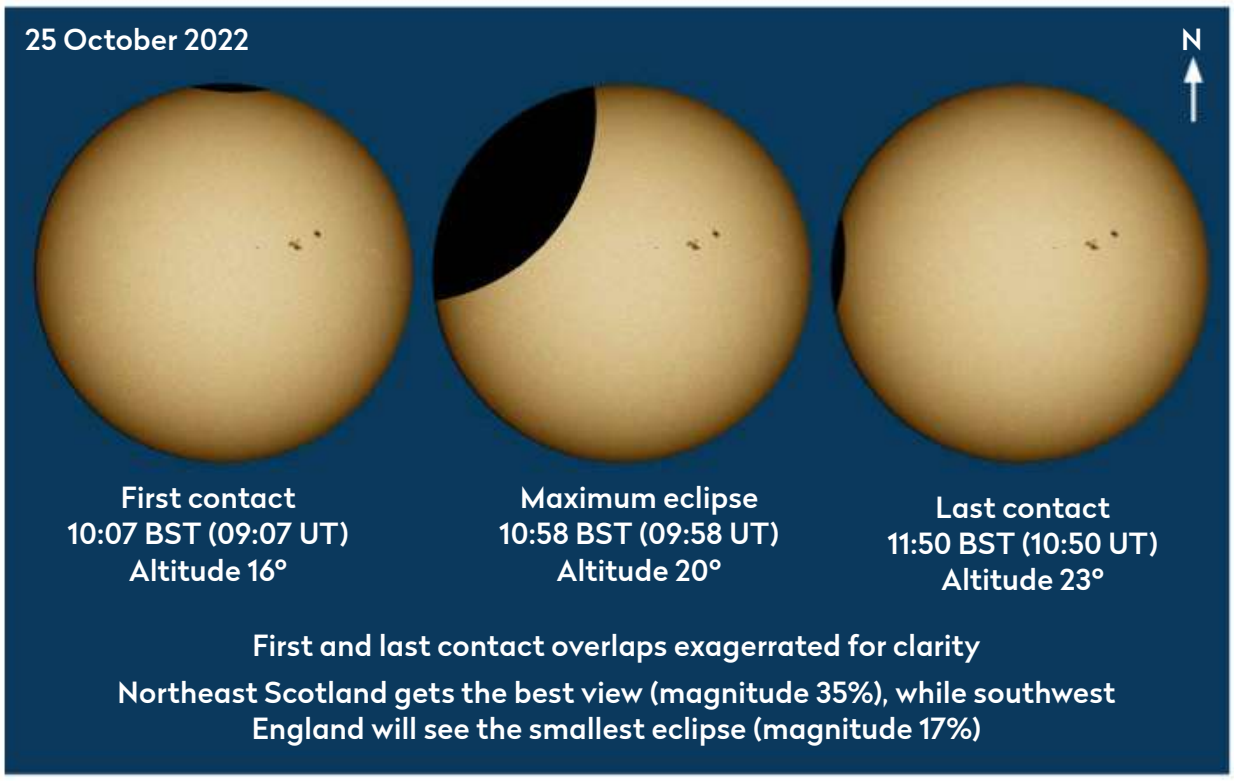
GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/10_easylessons** for our 10-step guide to getting started and **bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

Partial solar eclipse

BEST TIME TO SEE: 25 October, 10:00 BST (09:00 UT) until 12:00 BST (11:00 UT)


25 October 2022
N
First contact
10:07 BST (09:07 UT)
Altitude 16°
Maximum eclipse
10:58 BST (09:58 UT)
Altitude 20°
Last contact
11:50 BST (10:50 UT)
Altitude 23°
First and last contact overlaps exagerrated for clarity
Northeast Scotland gets the best view (magnitude 35%), while southwest England will see the smallest eclipse (magnitude 17%)

▲ **Timing of the partial solar eclipse as seen from central UK. Timings and eclipse coverage will vary depending on your location, with viewers in the east best-placed for the event**

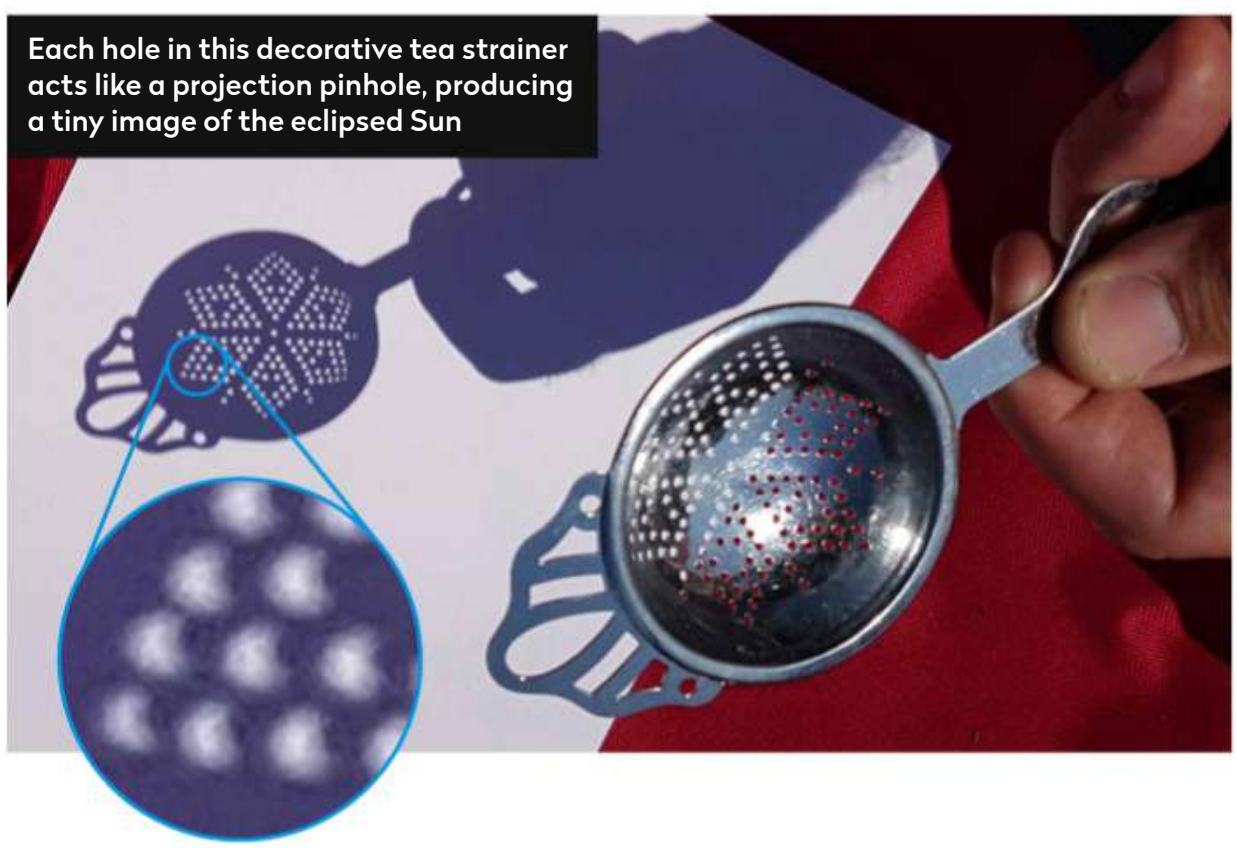
CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

After what seems like ages since the last solar eclipse visible from the UK – a partial which took place on 10 June 2021 – we get the chance to see a partial eclipse on the morning of 25 October. Partial solar eclipses happen when, from a particular location on Earth, only part of the Sun's disc is covered by the Moon's disc. Technically, during such an eclipse, it's the Moon's penumbral shadow passing over us.

The amount of the Sun's disc which is covered is described by two quantities: eclipse magnitude and obscuration. Eclipse magnitude describes how far the eclipsing body extends over the diameter of the object being eclipsed. For example, if the Moon's edge reached the mid-point of the Sun at the point of maximum eclipse, this would be described as a partial eclipse of magnitude 50%; the Moon covers half the Sun's apparent diameter. Eclipse obscuration describes how much area is covered. In our example, where the Moon moves to a position where its edge touches the centre of the Sun's disc, the obscuration would be 39.1%, assuming the apparent diameter of the Sun and Moon were the same. In practice there are small differences between the apparent size of the Sun and Moon caused by the elliptical orbit of the Moon around Earth and the elliptical orbit of Earth around the Sun.

This partial solar eclipse favours those living further east and to a lesser extent, further north. For example, from Truro in Cornwall the event starts at 10:12 BST (09:12 UT) and ends at 11:38 BST (10:38 UT), a total duration of 86 minutes. The maximum magnitude of the Truro eclipse is 17.66% and obscuration is 8.65%. From Birmingham the eclipse starts at 10:07 BST (09:07 UT) and runs for 101 minutes, with maximum magnitude 25.65% and 14.95% obscuration. York's starts at 10:06 BST (09:06 UT), lasts for 106 minutes, and shows a maximum magnitude of 29.29% and obscuration of 18.13%. From the northeast tip of Shetland it begins at 10:01 BST (09:01 UT), runs for almost two hours, shows a maximum magnitude of 40.96%, while the obscuration is 29.38%.

As this is a partial eclipse, appropriate filter protection must be used to keep your eyes and equipment safe. Certified eclipse glasses will show the bite taken out of the Sun well. Alternative low-tech visualisation methods include creating a pinhole or similar multi-holed projection setup. A pinhole in a piece of card can be used to cast a shadow onto a light surface, the light passing through the hole being a small image of the Sun. A metal tea strainer makes a surprisingly good shadow-caster for this purpose.



ALL PICTURES: PETE LAWRENCE

Thin Moon and Mercury

BEST TIME TO SEE: Morning of 24 October, from 07:00 BST (06:00 UT)

The visibility of the thinner crescent phases of the Moon is optimised around the equinoxes. Around the March equinox, it's the waxing crescents that are well placed, the ecliptic making a steep angle with the western horizon at sunset. At this time of year, it's the morning crescents that are optimally placed, the ecliptic making a steep angle with the eastern horizon around sunrise. The Moon never wanders that far from the ecliptic, its orbit being tilted by around 5° to the ecliptic plane.

On the morning of 24 October, the thin waxing crescent Moon rises above the eastern horizon 90 minutes before the Sun and will have a phase of 2%. It should be easy to spot as it rises, as the sky will still be relatively dark. Approximately 30 minutes after the Moon has appeared, Mercury will pop up above the same point on the horizon. At a magnitude of -1.0 and under brightening twilight skies, the planet should be easy to spot too. The pair will be 4.1° apart as they climb in altitude.

◄ A sliver of a Moon followed by bright Mercury rise together just before sunrise

From the centre of the UK, the Moon will attain an altitude of 6° and Mercury 3° at 07:15 BST (06:15 UT).

This thin Moon should look particularly attractive as it should be showing the phenomenon of 'earthshine', where the night side of the Moon appears to glow gently against the surrounding sky. The effect is caused by sunlight reflecting off Earth, hitting the Moon and reflecting back towards Earth. If you were standing on the Moon's Earth-facing side in the nighttime portion, the Earth would appear almost full and around four times larger than the Moon appears in our sky. Being more reflective than the Moon also helps Earth bring light to the Moon's nearside night.

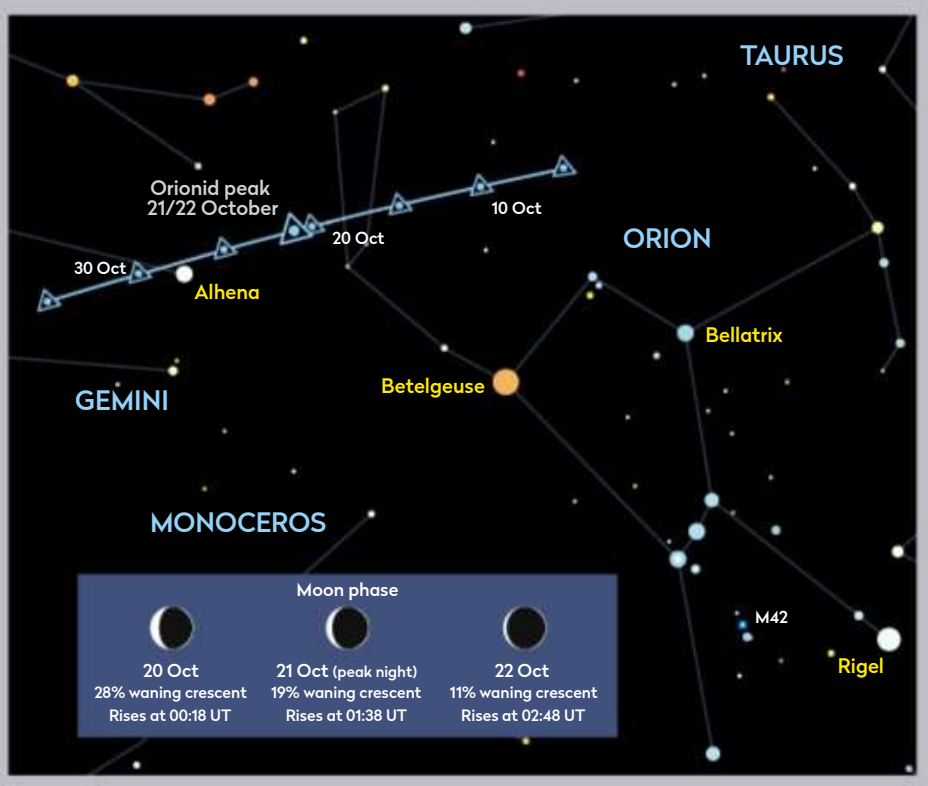
Orionids 2022

BEST TIME TO SEE: Night of 21/22 October

The Orionid meteor shower peaks on the night of 21/22 October. The shower produces a peak zenithal hourly rate (ZHR) of 20 meteors per hour, this representing the number of meteors you would see under perfect conditions with the meteor shower radiant – the point in the sky from which the shower trails appear to come from – directly over your head. In reality, hardly any of these conditions are met and so the visual hourly rate, the number of meteors you'll actually see, will be significantly lower than the ZHR.

Orionid meteors are the result of Earth passing through the orbital dust stream of comet 1P/Halley. The Orionids can produce good trails as long as you give yourself time to become properly dark adapted and spend a period of at least 30–60 minutes outside, looking up. This year an 11%-lit waning crescent Moon rises around 03:50 BST (02:50 UT) and shouldn't cause too much of an issue.

Find a comfortable location away from artificial lights and with a clear horizon. Wrap up warm and look up at an altitude of around 60°. Any direction will do, the south having some good constellations to enjoy. The radiant position is close to Betelgeuse, and trails near this point will appear shortest, while those 90° from this point appear longest.



▲ With little Moon interference, look to the radiant near Betelgeuse

THE PLANETS

Our celestial neighbourhood in October

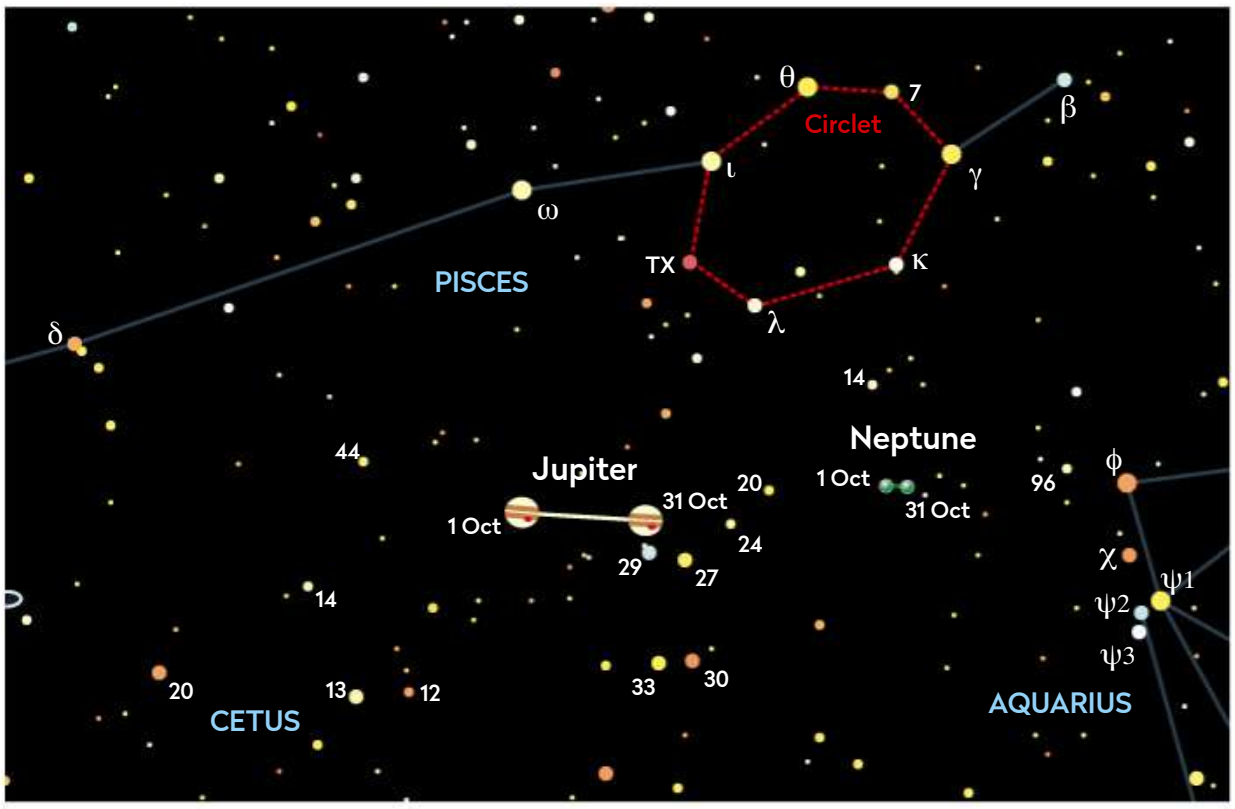
PICK OF THE MONTH

Neptune

Best time to see: 1 October, 23:00 UT
Altitude: 33°
Location: Aquarius
Direction: South
Features: Colour, occasional atmospheric effects, Triton
Recommended equipment: 200mm or larger

Neptune was at opposition in the middle of September and remains very well placed for observation from the UK throughout October. By the end of the month, shining at mag. +7.8, Neptune and mag. –2.6 Jupiter will appear separated by just 6.7°, both planets being located below the faint Circlet asterism in Pisces. The separation continues to reduce into next month, reaching a minimum of around 6.1° in late November.

At mag. +7.8, Neptune is too faint to be seen with the naked eye, theoretically being the only one of the main planets that needs optical assistance to see. In reality, it's difficult to spot Uranus too, which often lurks on the threshold of naked-eye visibility, and binoculars are your best choice to try to secure a view of both worlds.



▲ **Faint Neptune and brighter Jupiter will be close companions near the Circlet all month**

Through a 75mm telescope at high power, it's possible to get a feel that Neptune's blue-hued dot isn't a star, but a larger scope, say over 150mm diameter, is recommended to confirm this view. If you suspect you've got it in your field of view but aren't sure, centre it and gradually increase the power. If the atmospheric stability (seeing) is poor, don't go too high with the magnification. A power of 150x or more should reveal Neptune as a planet.

▲ **Neptune and its largest moon Triton: viable targets for 200mm scopes**

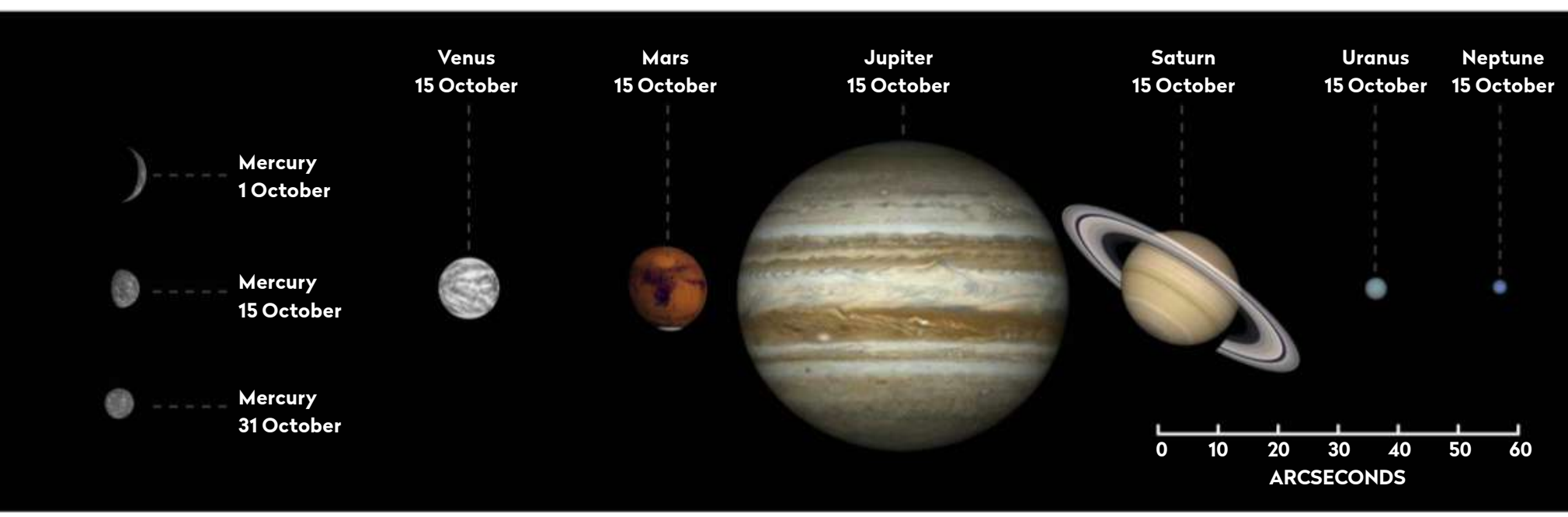
PETE LAWRENCE X 2

The larger the aperture you use the easier it will be to see Neptune's tiny 2.4-arcsecond disc. Large planetary imaging setups may, on occasion, pick up vague detail within the planet's atmosphere, including banding and large-scale storms.

Being the most distant of the main planets, Neptune doesn't give up its secrets easily, but amazingly its largest moon, Triton, can be seen quite easily through a 200mm instrument. Triton shines at mag. +13.5.

The planets in October

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 8 October, 30 minutes before sunrise
Altitude: 12°
Location: Virgo
Direction: East

A morning planet on 1 October, mag. +1.4 Mercury rises 70 minutes before the Sun. It improves markedly and by 8 October at mag. –0.2, reaches greatest western elongation, rising 100 minutes before sunrise. It remains well-placed to around 20 October, at mag. –0.9. It remains bright, but its rising offset from the Sun then reduces. On 24 October, mag. –1.0 Mercury, preceded by a 1%-lit Moon, rises an hour before the Sun. By the end of the month, the rise time offset decreases to just 30 minutes.

Venus

Best time to see: 1 October, 20 minutes before sunrise
Altitude: 2° (extremely low)
Location: Virgo
Direction: East

Rising just 40 minutes before the Sun on 1 October, mag. –3.8 Venus is now becoming hard to see. Venus reaches superior conjunction on 22 October, thereafter re-emerging into the evening sky.

Mars

Best time to see: 31 October, 03:00 UT
Altitude: 61°
Location: Taurus
Direction: South

Mars is now a major planet in the late evening to early morning sky. Rising in the northeast around 20:30 UT on 1 October, it reaches 60° as dawn breaks. Shining at mag. –0.6 on this date, it presents an apparent disc size of 11 arcseconds. Passing just over 1° north of the Crab Nebula, M1, mid-month, Mars is joined by a 73%-lit Moon 3° to the north on 15 October. As the month ends, Mars shines at mag. –1.2 and is 15 arcseconds across.

Jupiter

Best time to see: 1 October, 23:40 UT
Altitude: 37°
Location: Pisces
Direction: South

Following opposition, Jupiter remains superbly positioned. On 1 October, it shines at mag. –2.8, east and slightly south of the Circlet asterism in Pisces. On 8 October, it is joined by an almost full Moon less than 3° to the south as they rise. By 31 October, it appears at mag. –2.7 and reaches its highest position in the sky, due south at 21:30 UT, at an altitude of 35° from the centre of the UK.

Saturn

Best time to see: 1 October, 21:00 UT
Altitude: 21°
Location: Capricornus
Direction: South

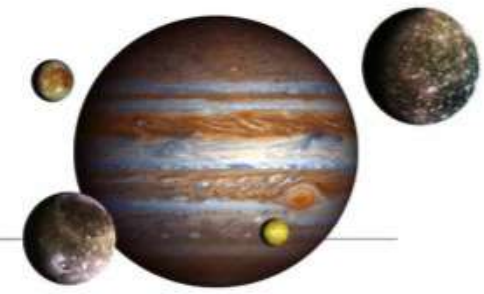
At mag. +0.6 on 1 October, dimming to mag. +0.8 by the end of the month, Saturn reaches its highest position due south, under dark sky conditions all month, reaching 20° altitude as seen from the centre of the UK. A bright 81%-lit Moon lies nearby on the evening of 5 October.

Uranus

Best time to see: 31 October, 00:30 UT
Altitude: 53°
Location: Aries
Direction: South

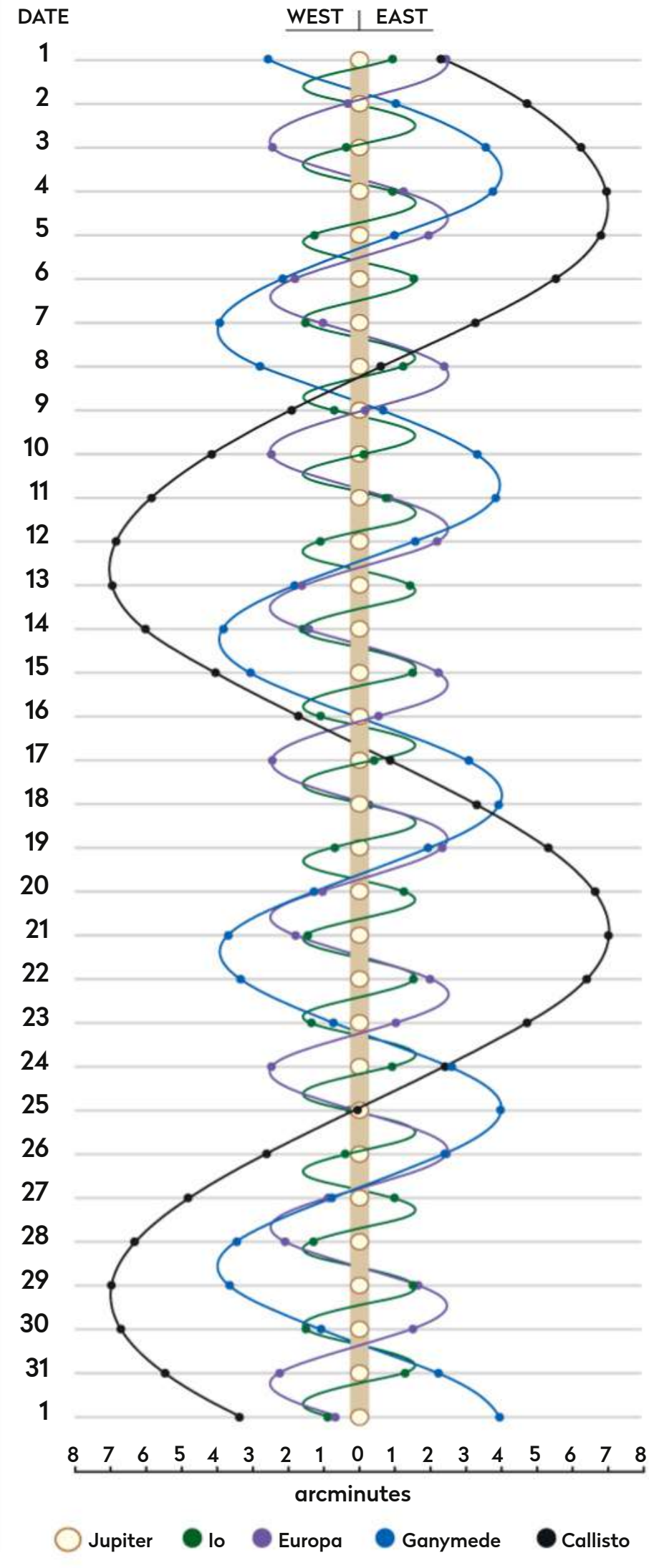
Uranus is extremely well-placed for UK viewing, appearing over 50° up when due south, from the centre of the UK. A 94%-lit waning gibbous Moon lies 2.5° west at 01:50 UT on 12 October.

More **ONLINE**
Print out observing forms for recording planetary events



JUPITER'S MOONS: OCTOBER

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT.)



THE NIGHT SKY – OCTOBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- 5° N E W S — COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

1 October at 01:00 BST
15 October at 00:00 BST
31 October at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in October*

Date	Sunrise	Sunset
1 Oct 2022	07:11 BST	18:47 BST
11 Oct 2022	07:29 BST	18:23 BST
21 Oct 2022	07:48 BST	18:01 BST
31 Oct 2022	07:07 UT	16:40 UT

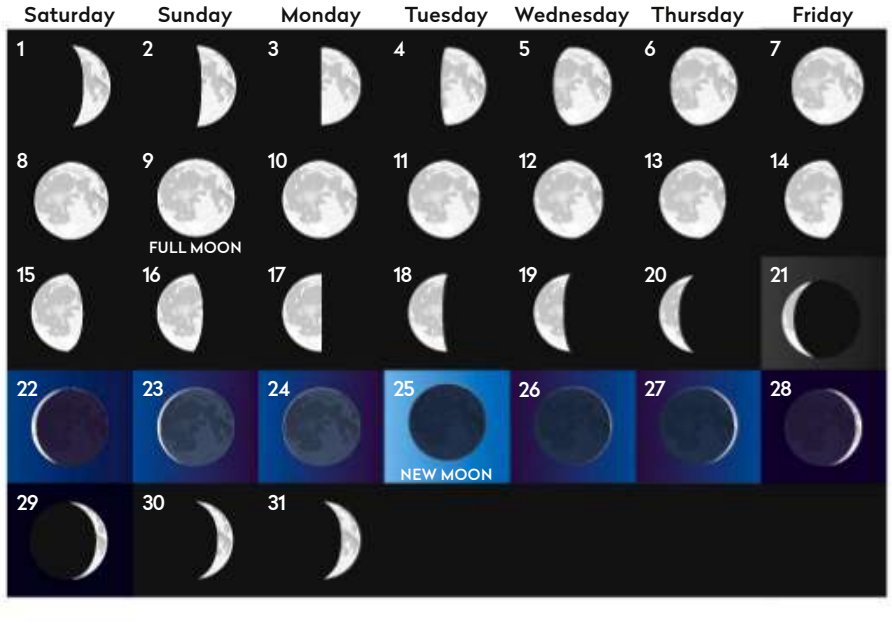
Moonrise in October*

Moonrise times

1 Oct 2022, 14:28 BST	17 Oct 2022, 22:41 BST
5 Oct 2022, 17:43 BST	21 Oct 2022, 02:25 BST
9 Oct 2022, 18:37 BST	25 Oct 2022, 07:45 BST
13 Oct 2022, 19:37 BST	29 Oct 2022, 13:34 BST

*Times correct for the centre of the UK

Lunar phases in October



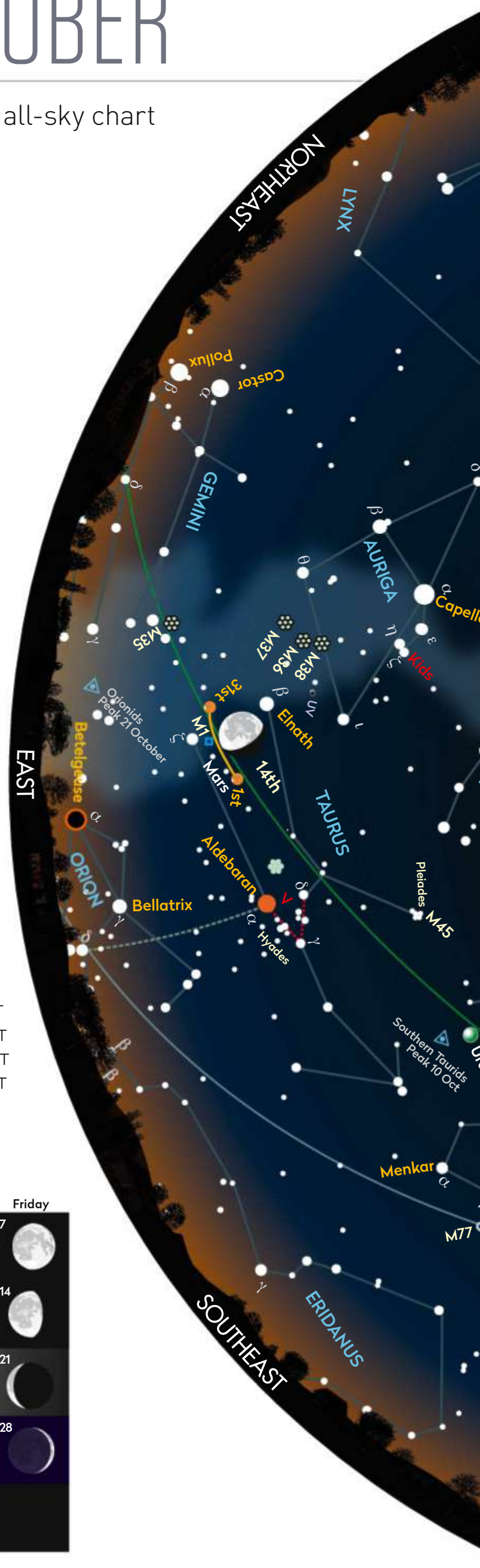
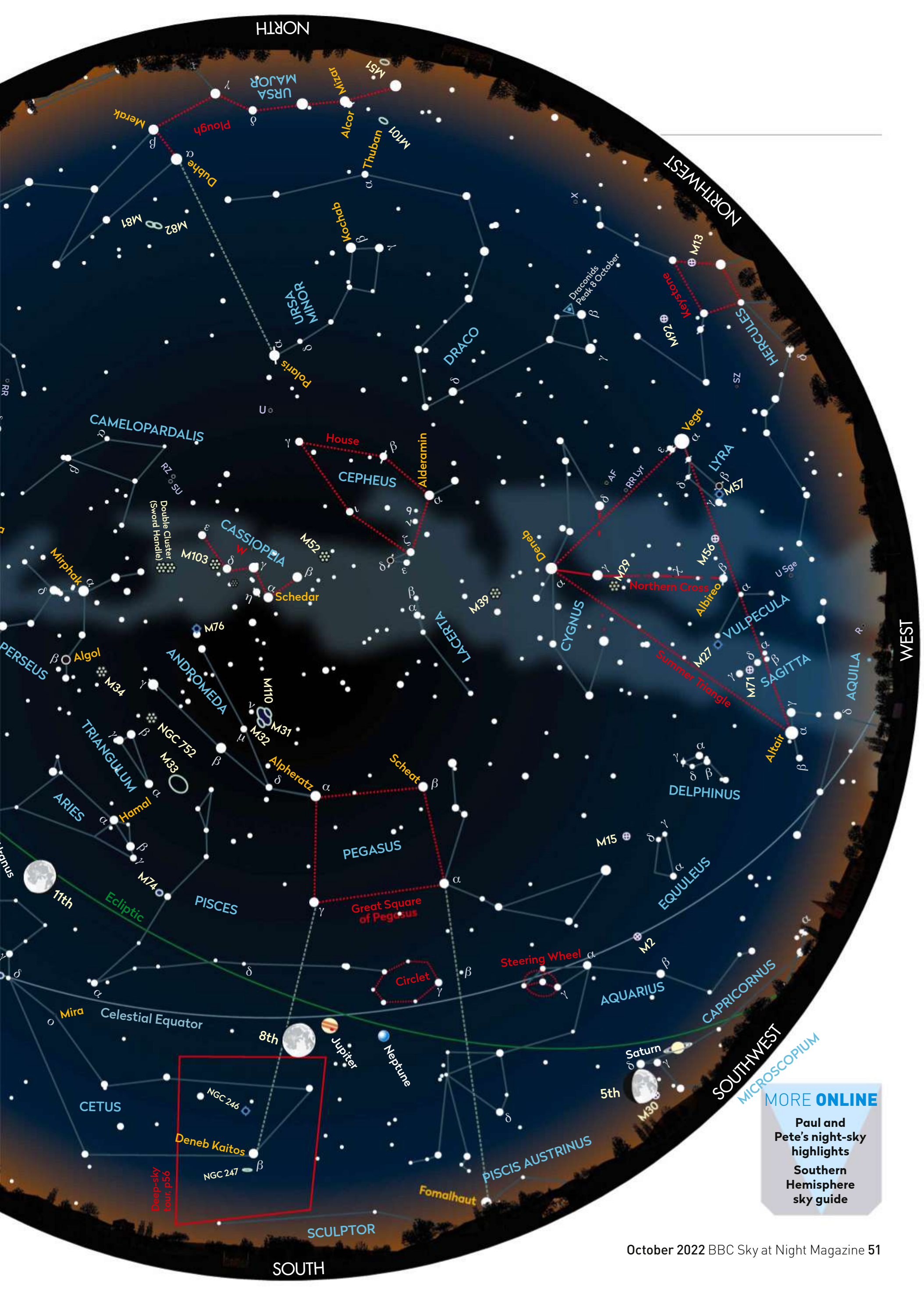


CHART: PETE LAWRENCE



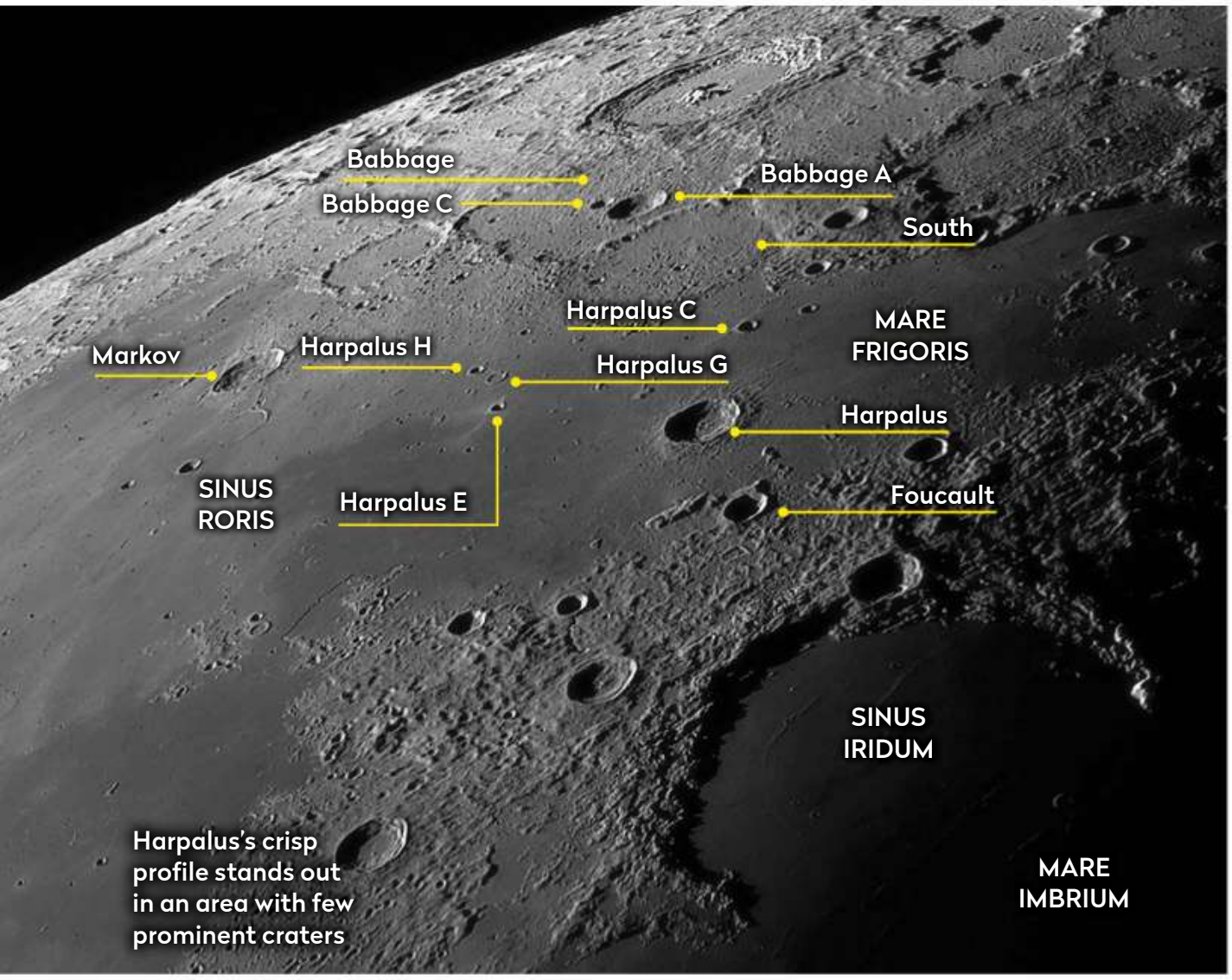
MORE **ONLINE**

Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

MOONWATCH

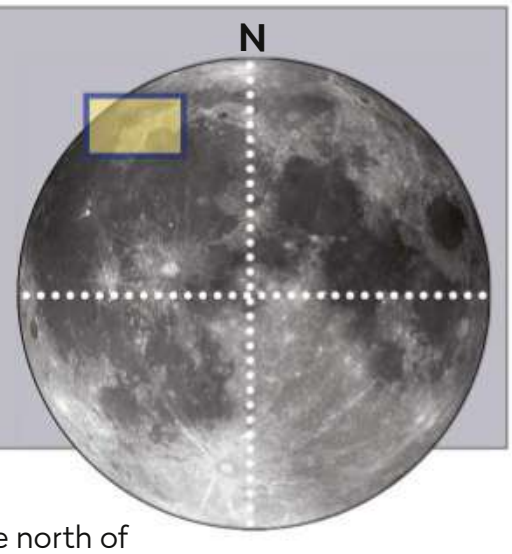
October's top lunar feature to observe



Harpalus's crisp profile stands out in an area with few prominent craters

Harpalus

Type: Crater
Size: 40km
Longitude/Latitude: 43.5° W, 52.7° N
Age: Less than 1.1 billion years
Best time to see: Four days after first quarter (6 October) or three days after last quarter (20–21 October)
Minimum equipment: 50mm refractor



Harpalus is a 40km crater located to the north of the distinctive **Sinus Iridum** or Bay of Rainbows, a semi-circular bay of lava located on the northwest shore of Mare Imbrium. It sits within the section of dark lunar lava which defines the western extremity of the elongated **Mare Frigoris**, the Sea of Cold. Measuring 1,800km long and 200km wide, Mare Frigoris can be seen running along the top of Mare Imbrium, easily identified to the north of the distinctive 101km, dark oval crater Plato. The region to the northwest of Harpalus, adjacent to 41km **Markov**, is **Sinus Roris**, the Bay of Dew.

Harpalus is a relatively young feature on the Moon's surface, estimated to be less than 1.1 billion years old. As such, its appearance is sharp and well-defined. A ray system surrounds the crater rim, with ejecta ramparts leading up to the outside edge of Harpalus. Inside the crater, a series of wall terraces lead down to a flat floor with three separated mountain peaks near the centre. All in all, the appearance is reminiscent of a miniature version of 93km Copernicus located south of the southern edge of the immense 1,250km **Imbrium Basin**. The bright and well-defined appearance of Harpalus's rays categorise it as being of an age bracket known as the **Copernican System**, Copernicus itself is estimated as being less than 1.1 billion years old.

From Earth, Harpalus appears elongated into an ellipse, a consequence of foreshortening. If viewed from an overhead vantage point, the crater would appear more circular, but there are a number of rim sections that show irregularity, notably those to the east. If you fancy a challenge, possibly best suited for large aperture instruments or high-resolution imaging, there's **a tiny 1.7km craterlet** on the floor of Harpalus, situated between the mountain complex and the southwest floor.

Harpalus's position within the western section of Mare Frigoris gives it some degree of prominence, the dark surrounding lava being nicely framed by the highland regions to the north and south. There's also a lack of other prominent craters in this area, the largest within this section of lava being 10km **Harpalus C** located 100km to the north.

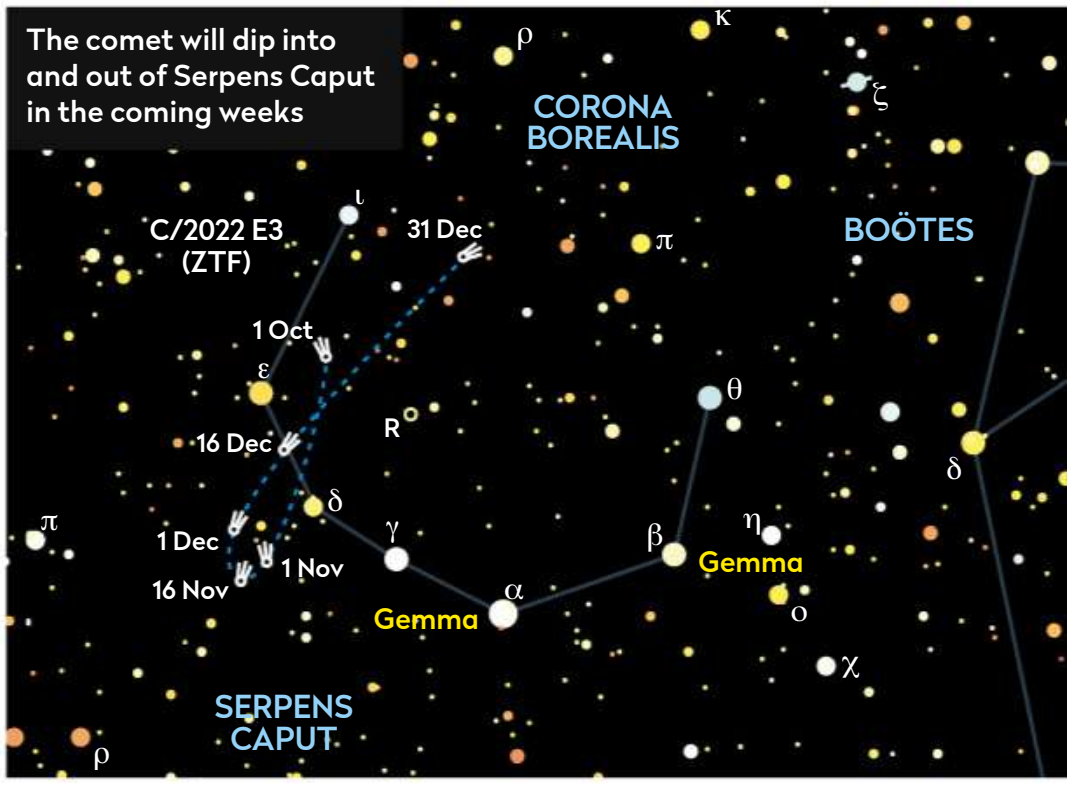
Between Harpalus and Sinus Iridum sits 23km **Foucault**, another sharp crater with a rectilinear mountain range touching its northern edge. Using Foucault as the starting point, draw a line from its centre through the centre of Harpalus and you'll arrive at the large and very ancient form of 108km **South**. This crater couldn't be further in appearance from Harpalus if it tried. Its ancient form is indistinct and its weathered floor pockmarked with many small craterlets. South is estimated to be older than 3.9 billion years, an age bracket known as pre-Nectarian. South abuts another ancient crater to the north, 144km **Babbage**. Like South, this has a very worn rim and a pock-marked interior dominated by 25km **Babbage A** and 14km **Babbage C**. To the northwest of Harpalus is an area with a trio of small craterlets, **Harpalus E, G and H**, with diameters of 7, 11 and 8km respectively.

A relatively young feature, its appearance is sharp and well-defined

PETE LAWRENCE X 3

COMETS AND ASTEROIDS

Brightening comet C/2022 E3 (ZTF) loops the loop in the Northern Crown



As brightening comet C/2017 K2 PanSTARRS has now moved too far south to be followed from the UK, all eyes will be turning to C/2022 E3 (ZTF), a comet currently in Corona Borealis. Its orbit, combined with the relative motion of Earth, has it performing a south-pointing loop into Serpens Caput before heading north out of the semicircle of stars which forms the distinctive constellation of the Northern Crown.

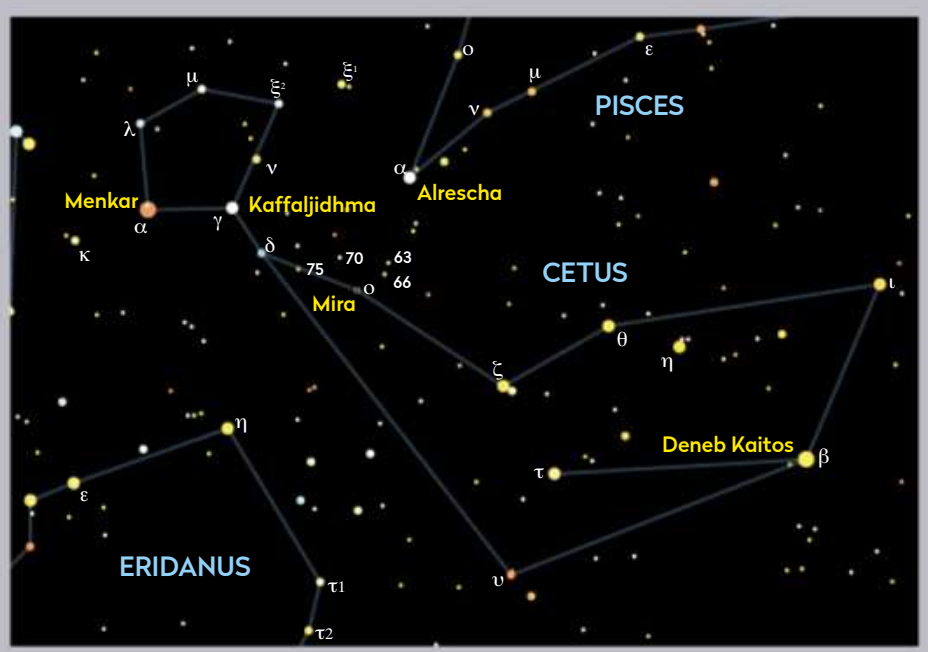
C/2022 E3 (ZTF) was discovered on 2 March 2022 using a 48-inch telescope at the Zwicky Transient Facility (ZTF) at Mount Palomar Observatory, California. It's due to reach perihelion on 13 January 2023 when it will lie 1.11 AU from the Sun. Its closest approach to Earth is on 2 February 2023, the distance between us and the comet dropping to 0.29 AU or 44 million kilometres.

Its brightness should increase as it approaches perihelion, due to its close proximity to the Sun, and as the distance between us and the comet reduces through to the start of February. At the start of October, C/2022 E3 is expected to be around mag. +11.7, brightening by one magnitude through the month. Its location in Corona Borealis means it's best seen in the evening sky, shifting to the morning sky as we head through November and on towards the end of the year. At the end of November C/2022 E3 is expected to appear around mag. +9.4, brightening to binocular range at mag. +7.6 by the end of December 2022. At perihelion on 13 January 2023, the comet is predicted to reach mag. +6.6. As it performs its closest approach to Earth on 2 February 2023, it's predicted to be a naked-eye object at mag. +4.8. Excitingly, it'll be well positioned for UK observing over this entire period.

STAR OF THE MONTH

Kaffaljidhma, a triple in Cetus the Whale

▼ **Kaffaljidhma sits either at the head or tail of the Whale, depending on how you interpret Cetus**



Cetus the Whale is a sprawling autumn constellation south of Pisces. Here it nudges into the band of sky described as the Zodiac and consequently the Moon and planets can find themselves inside Cetus from time to time. The outline resembles a whale with a head to the east and raised tail northwest. The stars tell a different story though, the Whale's tail being represented by a misshapen pentagon that contains Menkar (Alpha (α) Ceti), the name meaning 'nostril'. So the apparent tail is actually the head!

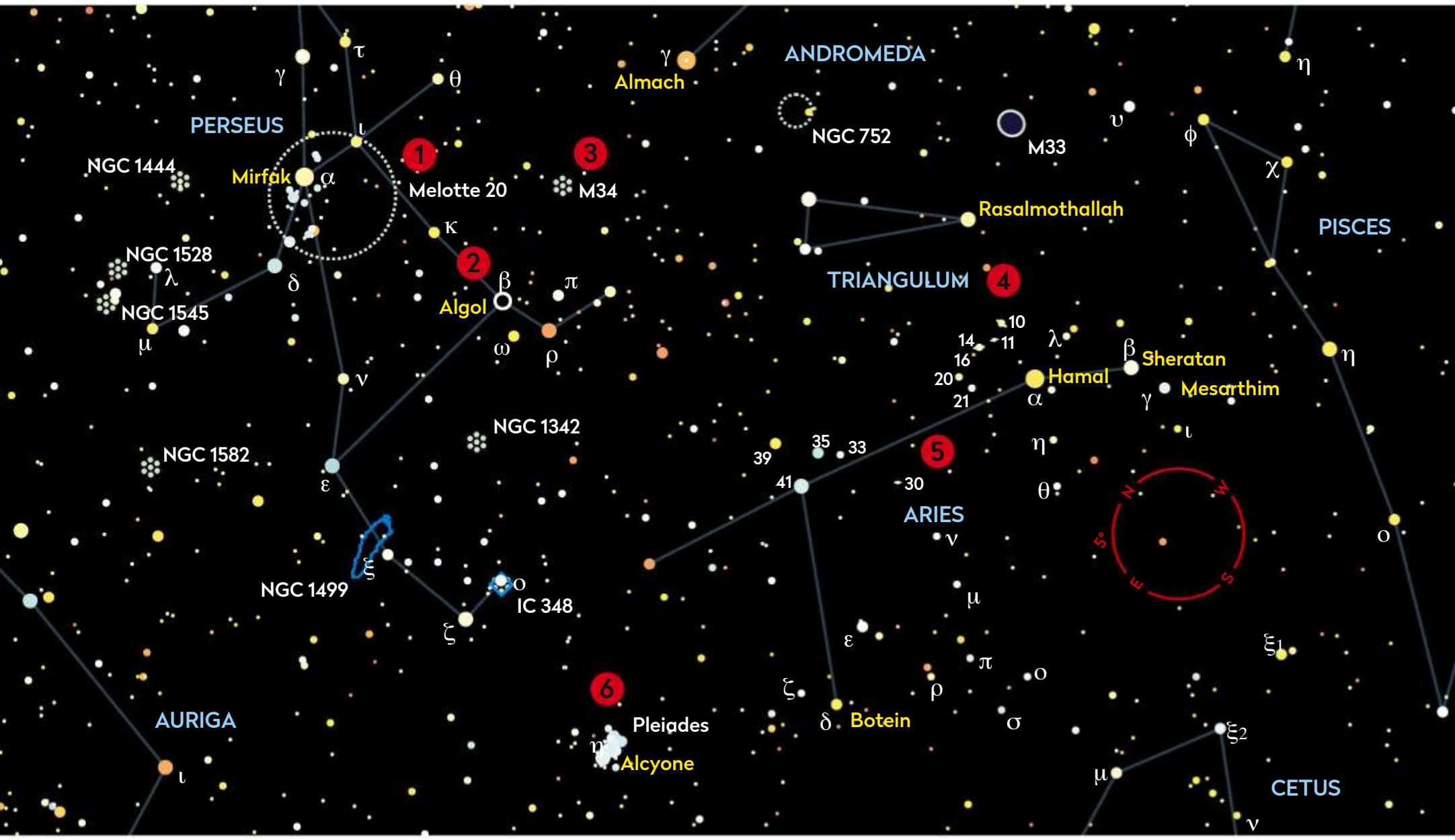
The base of the pentagon is Kaffaljidhma (Gamma (γ) Ceti) a shortened version of 'Al Kaff al Jidhmah', derived from the Arabic meaning 'the cut-short hand'. This name originally referred to a group of five stars in Cetus; Gamma, Xi^1 (ξ^1), Xi^2 (ξ^2), Delta (δ) and Mu (μ) Ceti. The Chinese Tiān Qūn refers to the asterism formed from Alpha, Kappa (κ), Lambda (λ), Mu, Xi^1, Xi^2, Nu (ν), Delta, 75, 70, 63 and 66 Ceti. Tiān Qūn translates to 'circular celestial granary', with Gamma Ceti known as 'the eighth star of circular celestial granary'.

Kaffaljidhma is a triple system. Through the eyepiece Kaffaljidhma A and B are easily resolved as a double, A being a mag. +3.6 A3 type star, B a mag. +6.3 cooler F3 type. Through a telescope this white-yellow pair are separated by 2.8 arcseconds and often look blue-yellow due to colour contrast. Mag. +10.1 Kaffaljidhma C is an orange star of type K5 and sits 0.25° from A and B. While A and B have a 320-year orbital period, C takes around 1.5 million years to orbit the other two. The system is 82 lightyears away, Kaffaljidhma A being around twice as massive as the Sun.

BINOCULAR TOUR

With Steve Tonkin

Stars, star, stars: this month it's all about spotting clusters and pairs



1. Melotte 20

10x 50 This stunningly beautiful cluster extends nearly 4° southeast from mag. +1.8 Mirfak (Alpha (α) Persei), with its hot young blue-white stars sparkling like diamonds on black velvet. It is only about 60 million years old. It's known as the Alpha Persei moving cluster because all the stars share a similar proper motion (motion relative to the celestial sphere) of around 33 milliarcseconds per year. ☐ **SEEN IT**

2. Algol

10x 50 If you want to dip your toe into variable star observing, Algol (Beta (β) Persei), is a good place to start, being at a convenient altitude on autumn evenings. It is an eclipsing binary star, meaning that it dips in brightness when the fainter member of the system passes in front of the brighter one. With Algol, this happens every 2.85 days, when its magnitude falls from +2.1 to +3.4 for about 10 hours. ☐ **SEEN IT**

3. M34

10x 50 If you pan across from Algol in the direction of mag. +2.1 Almach (Gamma (γ) Andromedae) you should find M34 approximately one field of view from Algol. You are seeking a fuzzy patch about 0.5° across. You should be able to resolve at least a dozen stars, the brightest of which form a distorted 'H' shape. You are looking at starlight that left this 220-million-year-old cluster some 1,400 years ago. ☐ **SEEN IT**

4. 10, 11 & 14 Arietis

10x 50 Here we have three pairs of stars in the same field of view. The components of 10 Arietis are magnitudes +5.7 and +7.1, separated by 9.5 acminutes, and appear slightly different shades of yellow, whereas those of 11 Arietis are +6.0 and +7.3, 7.7 arcminutes apart, and are much brighter white. The yellow-white components of 14 Arietis, which is actually a triple star, are +5.0 and +7.9, and much closer at 108 arcseconds. ☐ **SEEN IT**

5. 30 Arietis

15x 70 30 Arietis is a binary pair that, for some people, creates a curious optical illusion. The components, 38 arcseconds apart, shine at magnitudes +6.4 and +7.0 and are both of spectral class F5. This means that they should both appear a very pale yellowy-white but, for some reason, possibly an after-image effect, some people report the fainter of two as being blue- or lilac-tinged. What do you see? ☐ **SEEN IT**

6. Pleiades

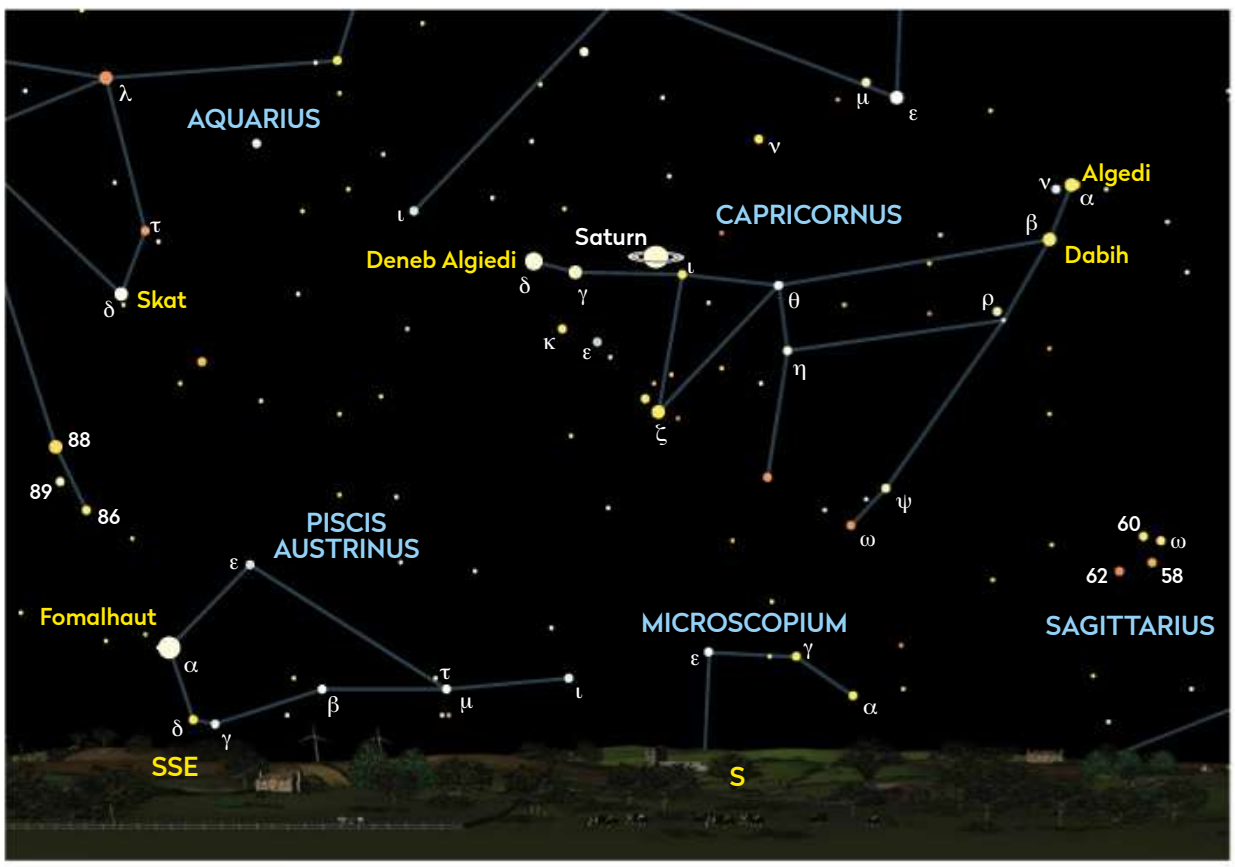
10x 50 Although you can see the blue-white stars of the Pleiades (M45), with your naked eye even in suburban skies, you really need binoculars to get the best out of it. Compare the view as this gorgeous open cluster rises and more and more stars become visible. It's hardly surprising that they have inspired poets from Sappho to A E Housman. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

How low can you go? Our challenge: find the most southerly object you can see



▲ **Find a flat southern horizon, locate Saturn and work your way down through Capricornus**

This month's Deep-Sky Tour on page 56 requires you to go low – down to southerly declinations that you probably wouldn't think about wandering into under normal circumstances. And perfectly understandable that is too, since low-altitude objects are compromised by the layer of thicker atmospheric murk which lurks near the horizon. But it is sometimes interesting to push your limits just to see how far south you can actually see from your own back garden or surrounding area. Your challenge this month is to see just how low you can actually go.

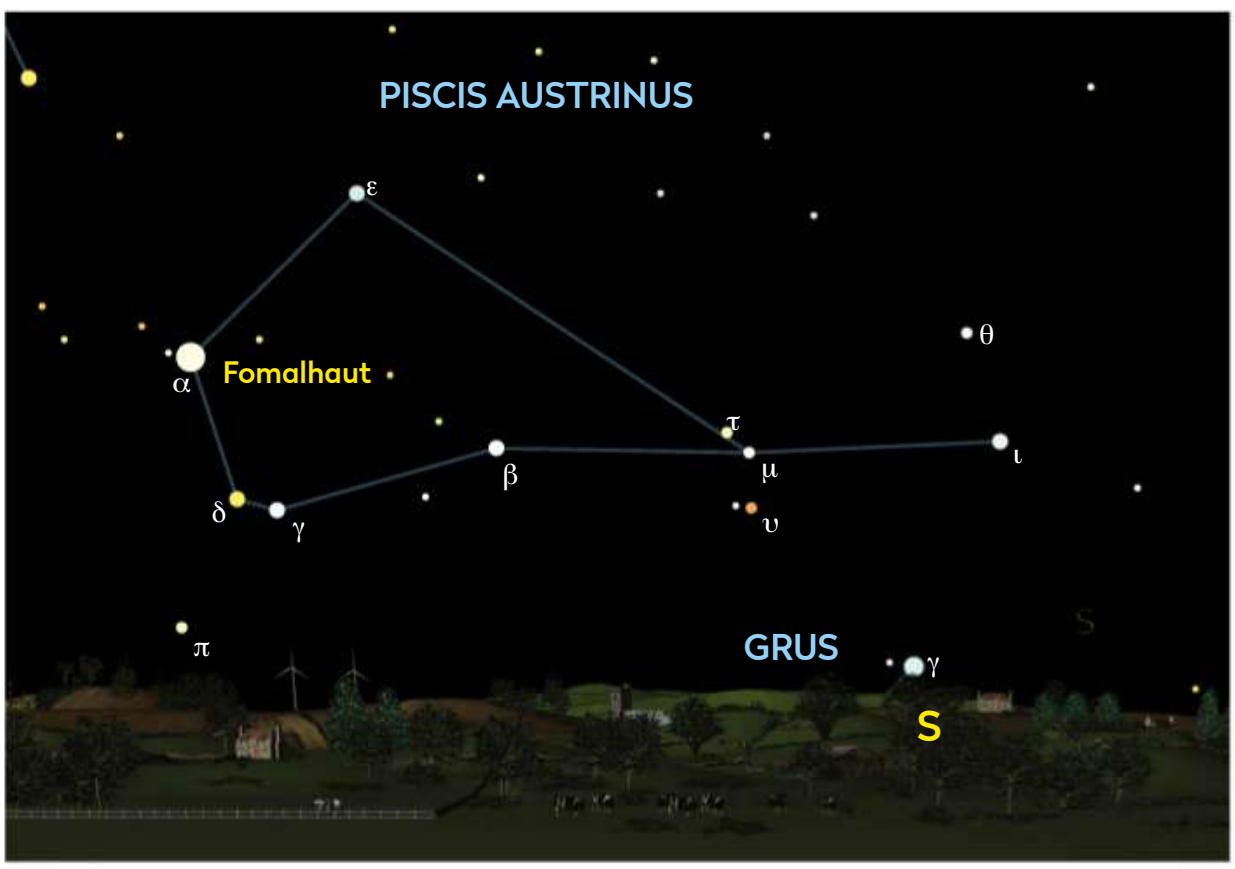
Yes, you can cheat for this and look at a planetarium program, but there's something quite amazing about putting in the effort and navigating to southern declinations yourself. If you're not overly familiar with the night sky, or perhaps not that familiar with the more southerly constellations, the challenge also adds a bit of celestial navigation into the mix and this is both useful and entertaining. If you don't fancy standing out in the cold to do this, then consider taking a photograph of your southern horizon which you can study in comfort, inside in the warm.

This challenge adds a bit of celestial navigation into the mix that's both useful and entertaining

What you can see will depend on what time you try, but we'd suggest starting out in the earlier part of the evening, say around 21:40 BST (20:40 UT) on 1 October, which equates to 20:40 BST (19:40 UT) on 15 October and 18:40 UT on 31 October. Looking south at this time will show you Saturn above the eastern section of the triangle of Capricornus. To the southeast of Saturn and very close to the south-southeast horizon, is bright, mag. +1.2 Fomalhaut (Alpha (α) Piscis Austrinus). If you can't see this star, consider trying again from somewhere with a flatter southern horizon.

From Saturn and using our chart, try to make out the form of Capricornus, right down to mag. +4.1 Omega (ω) Capricorni. Now comes the interesting part. Using sections of Capricornus as a sky ruler, try navigating south from Omega Capricorni towards the small group of faint stars that forms the constellation of Microscopium: mag. +4.9 Alpha (α) Microscopii, mag. +4.7 Gamma (γ) Microscopii and mag. +4.7 Epsilon (ε) Microscopii.

If you live anywhere south of 53° north latitude, look out for a brief appearance of mag. +3.0 Gamma (γ) Gruis which is at its highest around 25 minutes after the stated times above. We're stretching the meaning of 'highest' here though: when it's due south from a location at 53N latitude, Gamma Gruis just scrapes the horizon! If you live anywhere in the UK and have seen this star, drop us a line saying where you were and what the conditions were like.



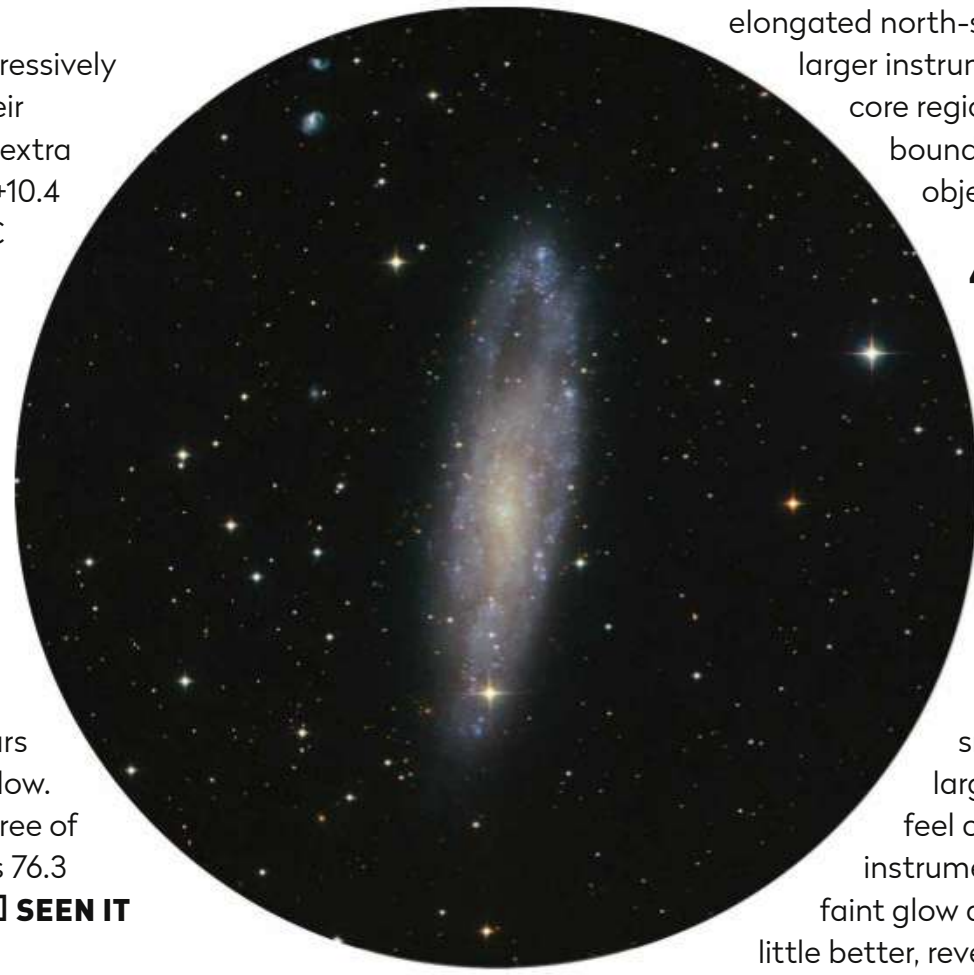
▲ **Try for bright Fomalhaut very close to the horizon and – a real test – Gamma Gruis**

DEEP-SKY TOUR

We take a deep dive to hunt low-altitude targets around the west of Cetus the Whale

1 NGC 157

Our targets get progressively lower this month, their diminishing altitude adding an extra challenge. We start with mag. +10.4 intermediate spiral galaxy NGC 157, 3.8° east and a fraction north of mag. +3.5 Iota (ι) Ceti. An intermediate spiral is one which sits between the classifications of a barred and unbarred spiral. It's relatively easy for smaller instruments and is conveniently placed between two brighter field stars: mag. +8.5 HD 3144 and mag. +9.1 HD 3154. The galaxy appears as an elliptical 3x2 arcminute glow. Larger instruments show a degree of mottling in the core. NGC 157 is 76.3 million lightyears from Earth. ☐ **SEEN IT**



▲ NGC 247 may be large but this faint spiral galaxy will be a tricky one to find

2 NGC 246

Our next object is a planetary nebula 4.7° southeast of NGC 157. Its position forms the southern apex of an equilateral triangle with Phi[1] (φ[1]) and Phi[2] (φ[2]) Ceti. It has an integrated magnitude of +10.4 but thanks to its large apparent diameter of around 4 arcminutes, it has a low surface brightness and appears faint. Despite this, it's easily visible through a 150mm instrument along with its relatively bright central star, white dwarf HIP 3678, which shines at mag. +11.8. Interestingly, this star, one of a binary pair, was recorded photographically at ninth magnitude in 1930 and has dimmed ever since. The nebula is 1,600 lightyears from Earth and is unofficially known as the Skull Nebula. ☐ **SEEN IT**

3 NGC 247

The declinations of our first and second targets were respectively –8° and –12°, but now things start to get a little trickier. NGC 247 is a bright, mag. +8.8 intermediate spiral galaxy sometimes classed as a dwarf spiral. It sits at declination –21°, 2.8° south and 1° east of Deneb Kaitos (Beta (β) Ceti) and just north of a small group of three-fifth magnitude stars. It's quite large at around 20x7 arcminutes but this means its surface brightness is low. Small telescopes show an elongated north-south spindle. A 300mm or larger instrument is required to show a small core region. NGC 247 is gravitationally bound to NGC 253, our fifth tour object. ☐ **SEEN IT**

4 NGC 45

Our next target has a declination of –23° and a magnitude of +10.4 but again suffers because of its large relative size. This, together with the fact that the galaxy's plane is inclined to our line of sight by 55°, results in an object of low surface brightness, probably too low for smaller instruments. Those with larger scopes have no reason to feel complacent though. A 250mm instrument shows little more than a faint glow and a 300mm instrument fares little better, revealing two slightly brighter regions. Coupled with low declination, NGC 45 certainly takes the title of this month's tour challenge object. ☐ **SEEN IT**

5 NGC 253

Located at declination –25°, slightly south of Cetus's southern border and into the constellation of Sculptor, NGC 253, the Sculptor Galaxy, is bright, easy to see even through smaller instruments and simple to locate 7.3° south of Deneb Kaitos. Its size is impressive, a 150mm instrument showing a 25x5 arcminute object. The best views are when it's due south. Through larger instruments it's magnificent, with mottled regions and a dark dust lane along its northwest side. This is another intermediate spiral galaxy, its low inclination presenting it as a long, thin ellipse. NGC 253 is also known as the Silver Coin or Silver Dollar Galaxy and is 11.4 million lightyears distant. ☐ **SEEN IT**

6 NGC 288

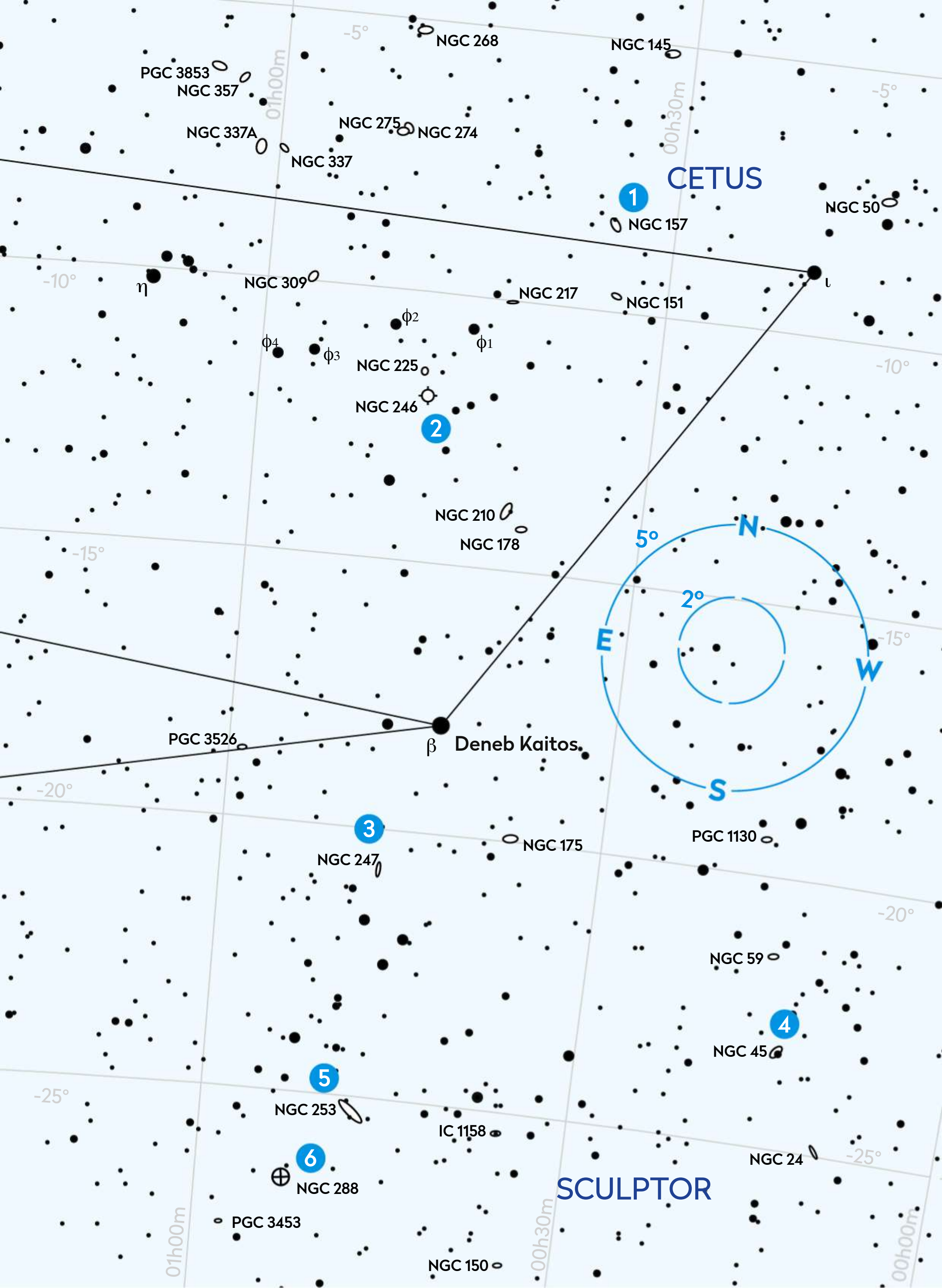
Our last object is a globular cluster. Listed at mag. +8.1, with a declination of 26.5°, NGC 288 sits even lower in the sky than our last target, NGC 253. It's 1.8° to the southeast of NGC 253 and relatively easy to see through smaller scopes. As an aside, it also sits 15 arcminutes from our own Galaxy's South Galactic Pole. It's a very diffuse globular which seems slightly elongated southeast–northwest through a 250mm or larger scope. Larger instruments may resolve many of the cluster's outer stars and the inner core region. Again, like NGC 253, the best time to try for NGC 288 is when it's due south and highest in the sky. ☐ **SEEN IT**

RUDOLF DOBESBERGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.


CETUS
SCULPTOR
PGC 3853
NGC 357
NGC 268
NGC 145
NGC 337A
NGC 337
NGC 275
NGC 274
NGC 157
NGC 50
NGC 309
NGC 217
NGC 151
NGC 225
NGC 246
NGC 210
NGC 178
PGC 3526
Deneb Kaitos
NGC 247
NGC 175
PGC 1130
NGC 59
NGC 45
NGC 253
IC 1158
NGC 24
NGC 288
PGC 3453
NGC 150
N
E
S
W
5°
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-10°
-15°
-20°
-25°
01h00m
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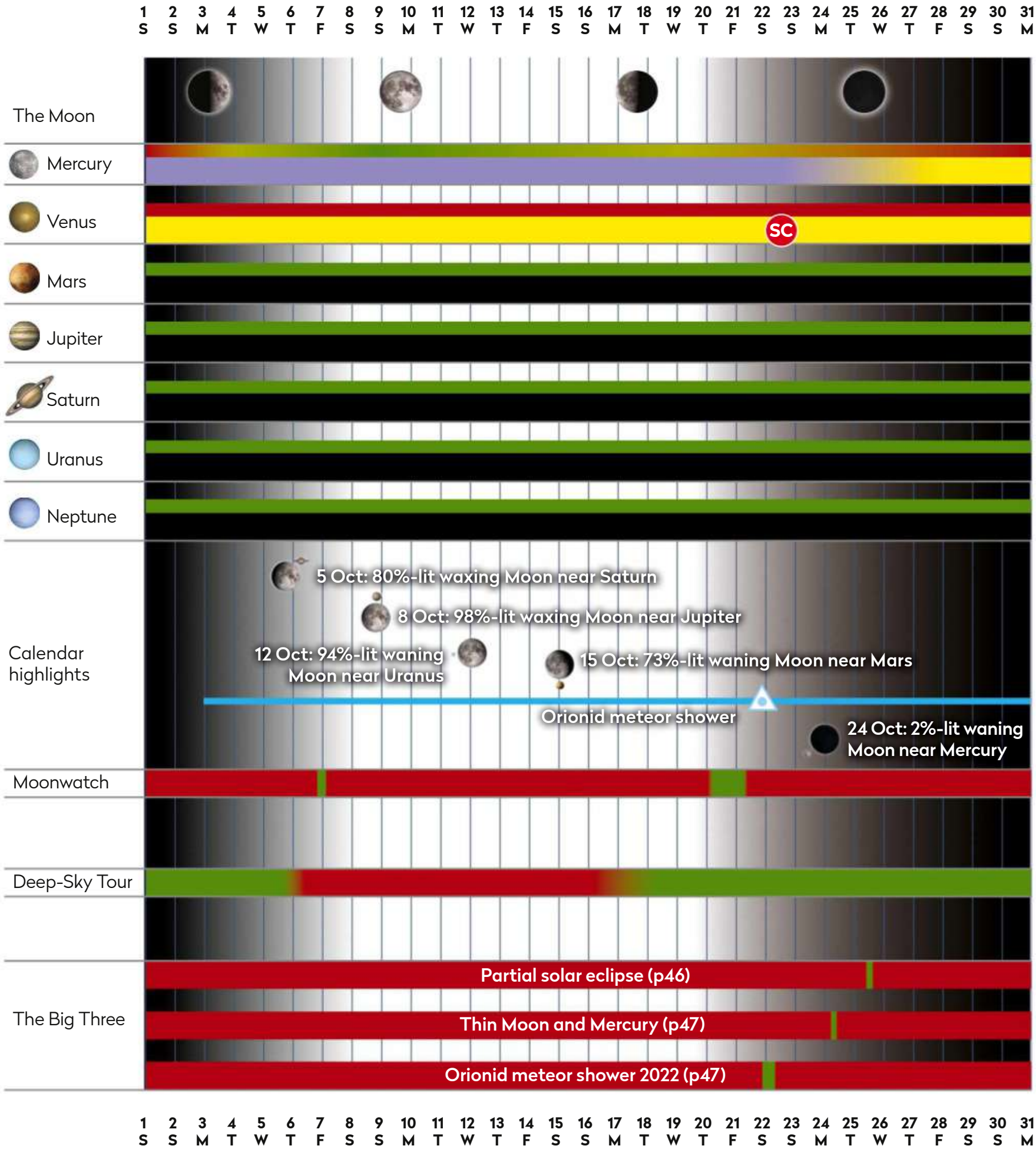
AT A GLANCE

How the Sky Guide events will appear in October


1 S 2 S 3 M 4 T 5 W 6 T 7 F 8 S 9 S 10 M 11 T 12 W 13 T 14 F 15 S 16 S 17 M 18 T 19 W 20 T 21 F 22 S 23 S 24 M 25 T 26 W 27 T 28 F 29 S 30 S 31 M
The Moon
Mercury
Venus
SC
Mars
Jupiter
Saturn
Uranus
Neptune
Calendar highlights
5 Oct: 80%-lit waxing Moon near Saturn
8 Oct: 98%-lit waxing Moon near Jupiter
12 Oct: 94%-lit waning Moon near Uranus
15 Oct: 73%-lit waning Moon near Mars
Orionid meteor shower
24 Oct: 2%-lit waning Moon near Mercury
Moonwatch
Deep-Sky Tour
The Big Three
Partial solar eclipse (p46)
Thin Moon and Mercury (p47)
Orionid meteor shower 2022 (p47)
1 S 2 S 3 M 4 T 5 W 6 T 7 F 8 S 9 S 10 M 11 T 12 W 13 T 14 F 15 S 16 S 17 M 18 T 19 W 20 T 21 F 22 S 23 S 24 M 25 T 26 W 27 T 28 F 29 S 30 S 31 M

KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

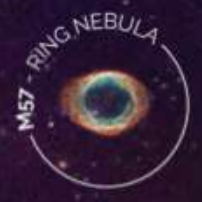
Last quarter

New Moon

CHART BY PETE LAWRENCE

UNISTELLAR

THE UNIVERSE AWAITS



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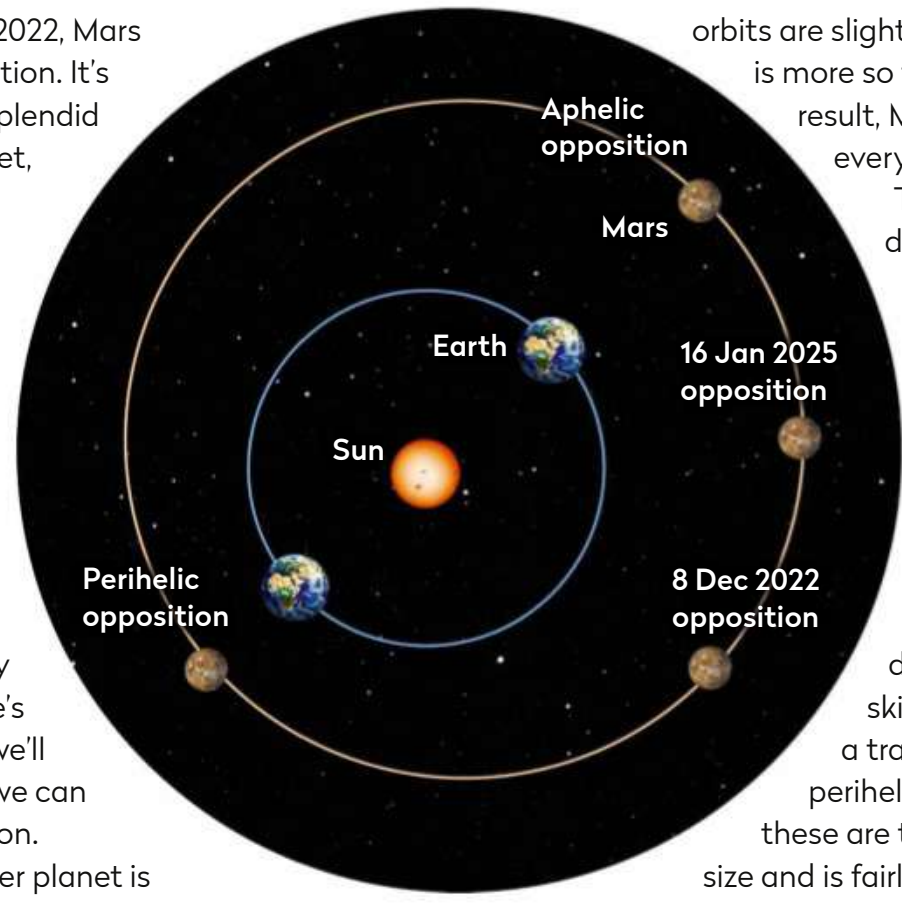
MARS SEASON HAS ARRIVED

With Mars at opposition this December – and a rare lunar occultation expected too – now's the time to start observing and tracking its changing features, writes **Paul G Abel**

On 8 December 2022, Mars reaches opposition. It's going to be a splendid telescopic target, well-placed for observation in the Northern Hemisphere and well worth observing in the dark winter months. And as an added bonus, on the same night as opposition the Moon will appear to pass in front of Mars in an event known as a lunar occultation. December is set to be the month of Mars. But before then, Mars will be growing steadily larger and brighter, meaning there's plenty to see in the run-up. Here we'll explore the exciting phenomena we can observe before and after opposition.

Opposition occurs when an outer planet is opposite the Sun in the sky. Sun, Earth and planet all lie in a straight line, with Earth in the middle, and at this time the planet is due south at midnight and visible all night. We don't get a Mars opposition every year, nor are they all favourable for UK observers. This is due to the shape of the Martian orbit. All planetary orbits are slightly elliptical, but the Martian one is more so than Jupiter's and Saturn's. As a result, Mars comes to opposition once every two years.



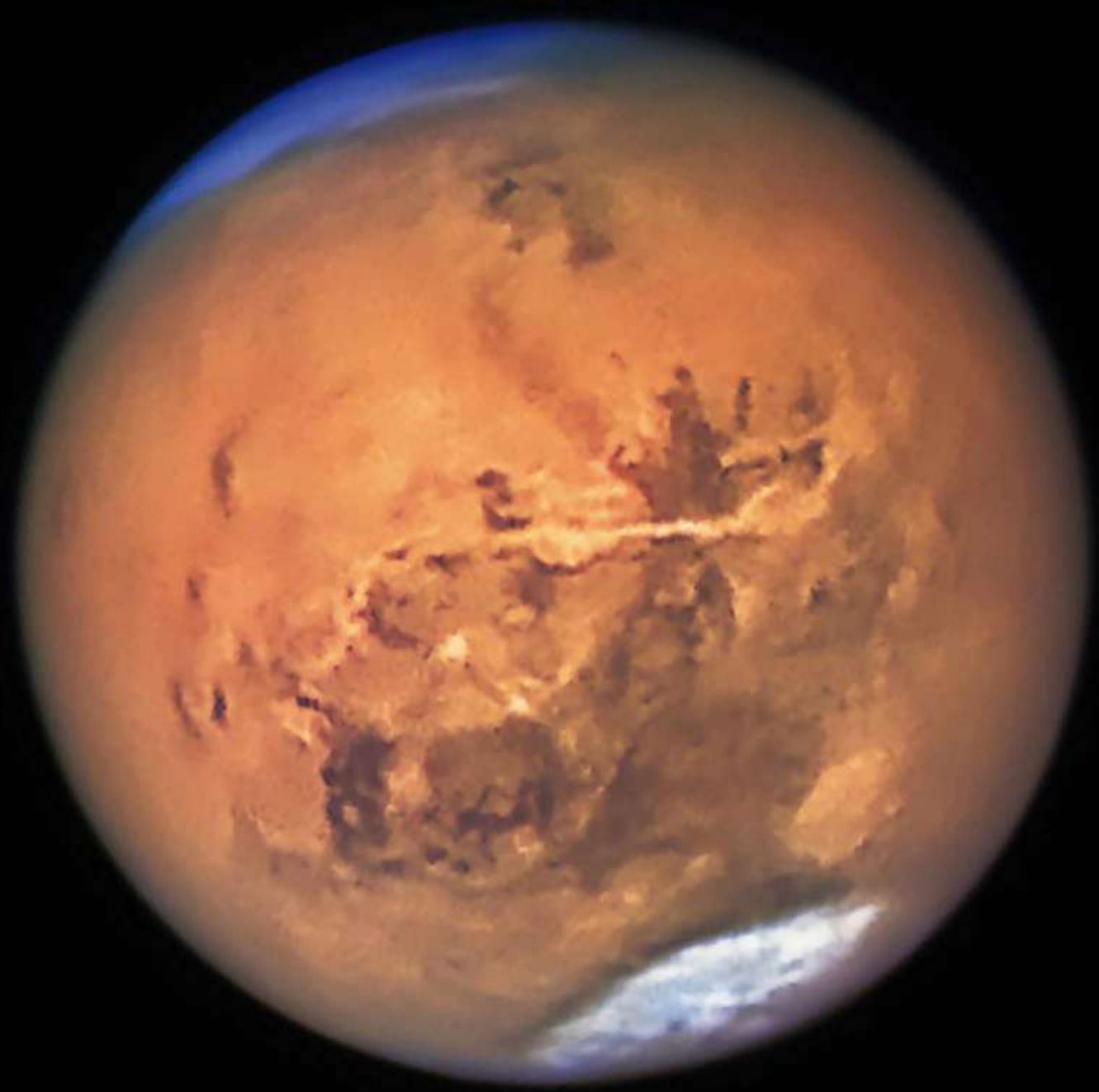
▲ **At perihelion, Mars is at the closest point to us in its elliptical orbit. Aphelion is the opposite**

The position of Mars in its orbit dictates its altitude in our skies at opposition. In a perihelic opposition, Mars is at (or near) perihelion (its closest point to the Sun). The planet is large and bright, but low down for Northern Hemisphere observers. In aphelic oppositions, Mars is at its furthest point from the Sun and has a small apparent diameter, but is high in UK skies. December's opposition is a transitional one: moving from perihelic to aphelic. In my opinion, these are the best: Mars reaches a good size and is fairly well placed.

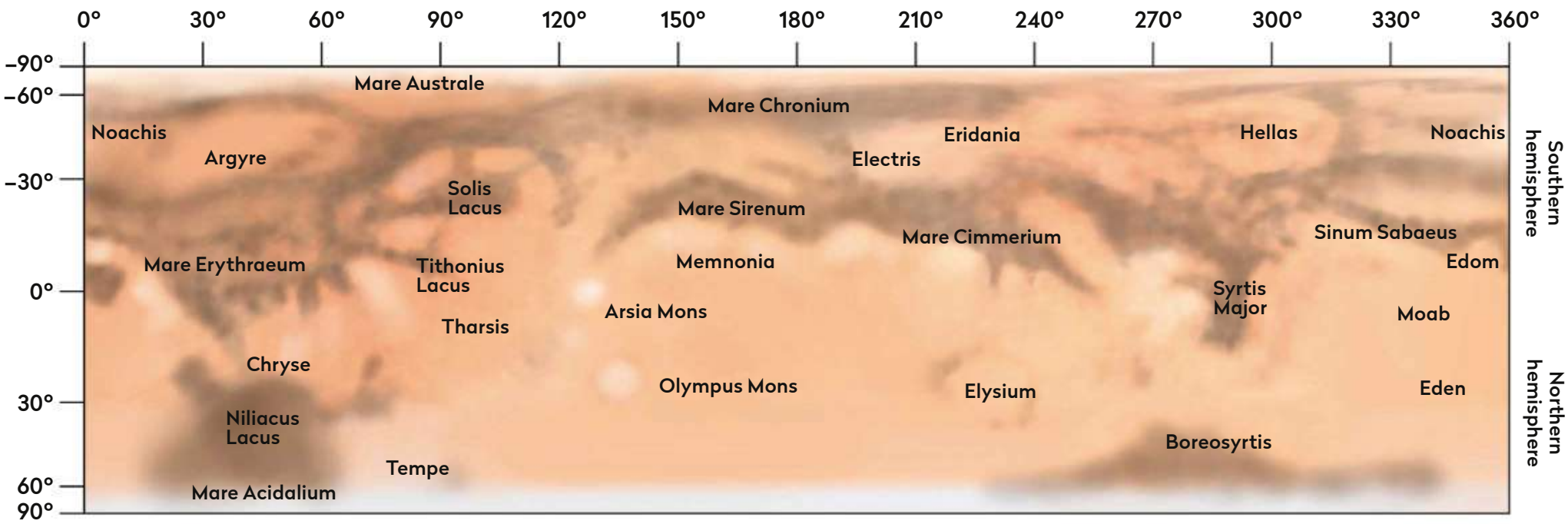
Get your bearings

The type of opposition affects not only altitude and apparent diameter, but also the tilt of Mars as we see it from Earth. Mars has an axial tilt of about 25° and the tilt, along with the orbit, means that during ▸

SEBASTIAN VOLTMER/CCDGUIDE.COM



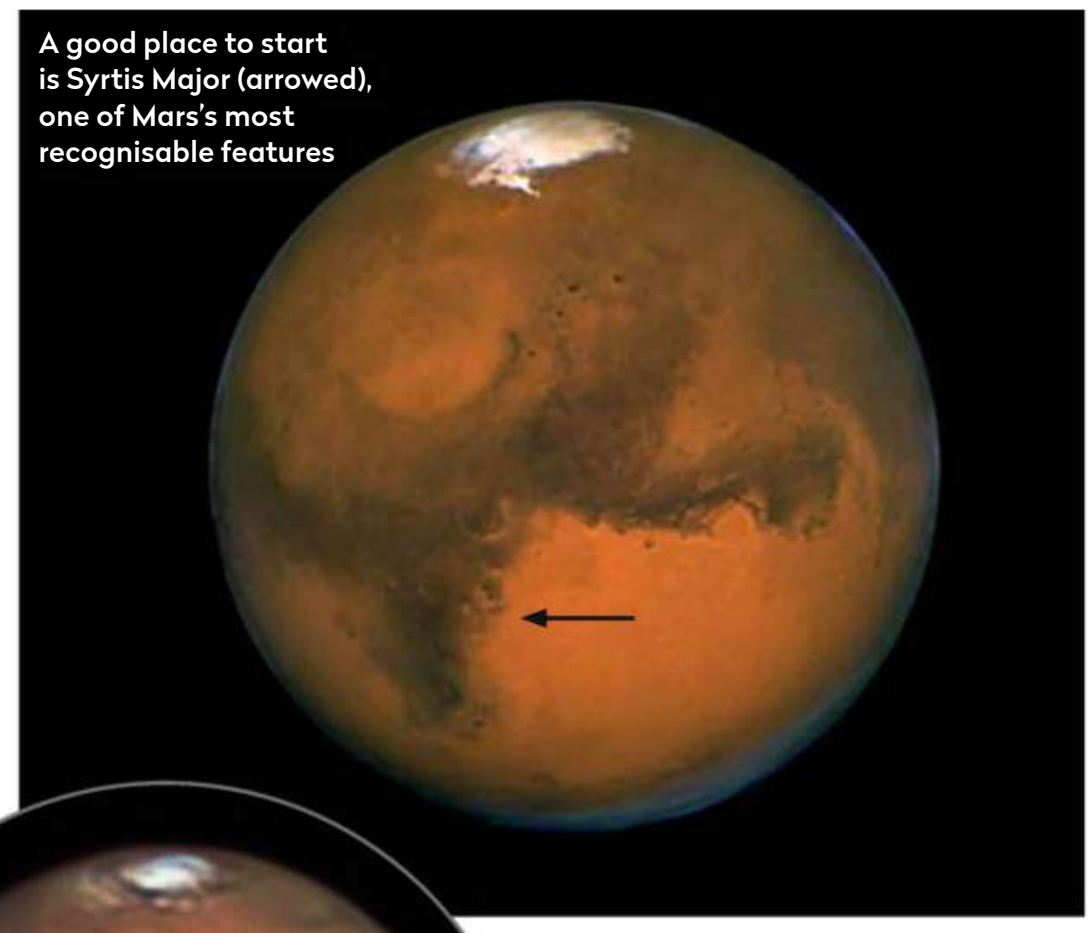
Red alert: there's a chance to simultaneously see both polar ice caps of a big, bright-shining Mars around opposition



▲ **An areocentric longitude (Ls) map of Mars's most well-known features (30° = 1 month); drawn with a mirror-inverting telescope (south up)**

▸ perihelic oppositions the southern hemisphere of Mars is tilted towards us. The tilt can be quite pronounced, meaning we have splendid views of the southern polar cap and surrounding regions. During aphelic ones, the northern hemisphere is presented and it can be almost impossible to see the far south. Transitional oppositions tend to favour the equatorial regions and so they're a chance to see both the north and south caps at the same time.

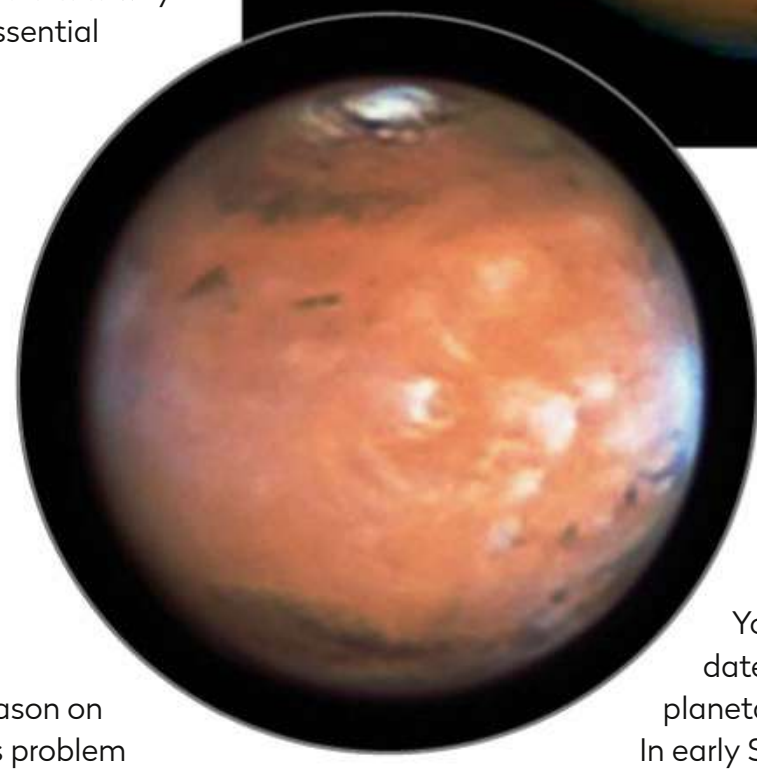
It will be helpful to learn some key Martian features, as this will enable you to identify the more obscure areas of Mars. The dark Syrtis Major is a good starting point as it has a very distinctive shape. Mars rotates once in 24 hours 37 minutes, so it takes about three weeks to view the entire Martian surface from one specific location on Earth. The USA, for example, will see a different part of Mars compared to the UK due to the time difference, and this is why international scientific cooperation is essential during a Mars opposition.



Seasonal changes

Mars is a dynamic world. Just like Earth it undergoes well-defined seasons. Although the Martian atmosphere is thinner than Earth's, it is sufficient to produce brilliant white clouds, dust storms and winds travelling half the speed of sound – and all of this is visible in our telescopes. Winds blow Martian dust about and, over many years, the new accumulations of dust can change certain surface features.

Mars's seasons bring many different phenomena, but how do we define a season on Mars? Astronomers long ago solved this problem and invented a quantity called 'areocentric longitude' or 'Ls'. We split the Martian orbit into 12 months (see the map above). Each of these months is 30° in Ls. Spring equinox in Mars's northern hemisphere occurs at Ls = 0° (this is also autumn in the south) and 'month 1' runs from 0° to 30°. Northern summer occurs at Ls = 90°, while the autumn equinox is at Ls = 180°. Finally, the northern winter solstice occurs at Ls = 270°.

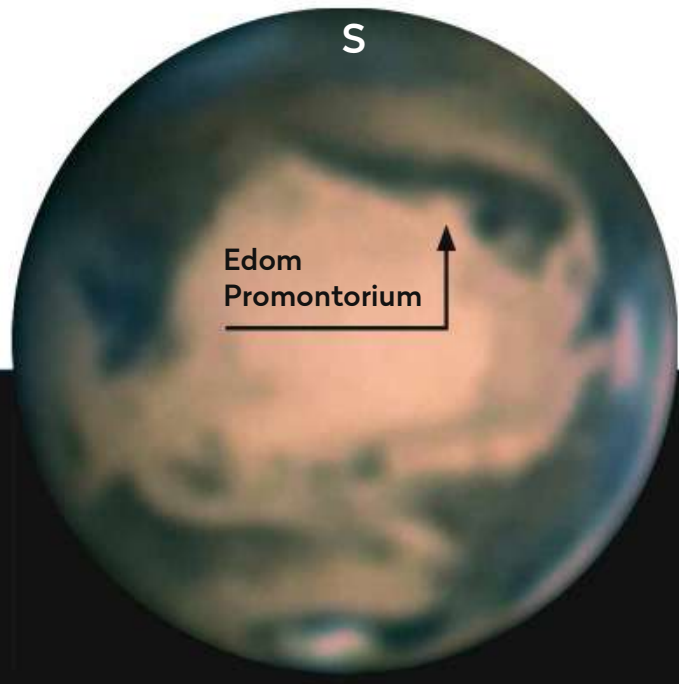


▲ **White clouds can form around some features, such as the tops of volcanoes or within valleys and ravines**

Mars becomes a viable target for medium and large telescopes when it has an apparent diameter of 6 arcseconds or more. This occurs between 11 May 2022 and 11 April 2023, during which we will see winter and spring in Mars's northern hemisphere, and summer and autumn in the south (Ls 225° to 50°). You can check what the Ls will be on a date with the free software WinJupos and planetarium software like Sky Safari.

In early September, Ls is about 297°. It is late autumn in the northern hemisphere and spring in the south. Mars has more of its northern hemisphere tilted towards us, and medium-sized telescopes should pick up the north polar cap, which is slowly melting. In contrast, the southern polar cap will be very small, having melted over the summer. September is the time to start looking for white clouds: they collect in large basins like Hellas, Argyre

PAUL ABEL, SEBASTIAN VOLTMER/CCDGUIDE.COM X 2, FRANZ KLAUSER/CCDGUIDE.COM



Light on Mars?

See if you can observe the famed flashes in Edom Promontorium

Catching the Edom flashes will require a medium telescope (6-inch reflector or 4-inch refractor) and a clear night, but not much more! Although observing the flashes may prove a little tricky, the challenge is well worth the effort and certainly achievable through an 8-inch reflector. If you do spot a flash, keep a record of what you see and you will be able to contribute to this very worthwhile scientific endeavour, helping astronomers learn more about the reflective nature of the Martian surface. We have made predictions as to when and where Edom flashes will occur based upon when the Sun–Earth–Mars geometry is aligned. Try observing on the dates and times suggested below. Note: the angle of the reflective plane will have a significant effect on when flashes will occur, so we recommend monitoring Edom for 90 minutes either side of the times stated.

For more on observing the Edom flashes, watch this month's Virtual Planetarium on our website (see p5 for details).

OCTOBER		NOVEMBER		DECEMBER	
DATE	BEST TIME (UT)	DATE	BEST TIME (UT)	DATE	BEST TIME (UT)
Wednesday 5th	22:00	Thursday 10th	19:25	Thursday 1st	06:50
Thursday 6th	22:40	Friday 11th	20:00	Friday 2nd	07:30
Friday 7th	23:15	Sunday 13th	21:10	Saturday 3rd	08:05
Sunday 9th	00:00	Monday 14th	21:50	Sunday 4th	08:40
Monday 10th	00:30	Wednesday 16th	22:55	Monday 5th	09:15
Tuesday 11th	01:10	Thursday 17th	00:00	Tuesday 6th	10:15
Thursday 13th	02:25	Saturday 19th	00:05	Wednesday 7th	10:55
Friday 14th	03:05	Sunday 20th	00:40	Sunday 18th	17:20
Saturday 15th	03:40	Tuesday 22nd	01:50	Monday 19th	17:55
Monday 17th	04:55	Wednesday 23rd	02:25	Tuesday 20th	18:35
Tuesday 18th	05:30	Thursday 24th	03:00	Wednesday 21st	19:15

Low probability High probability

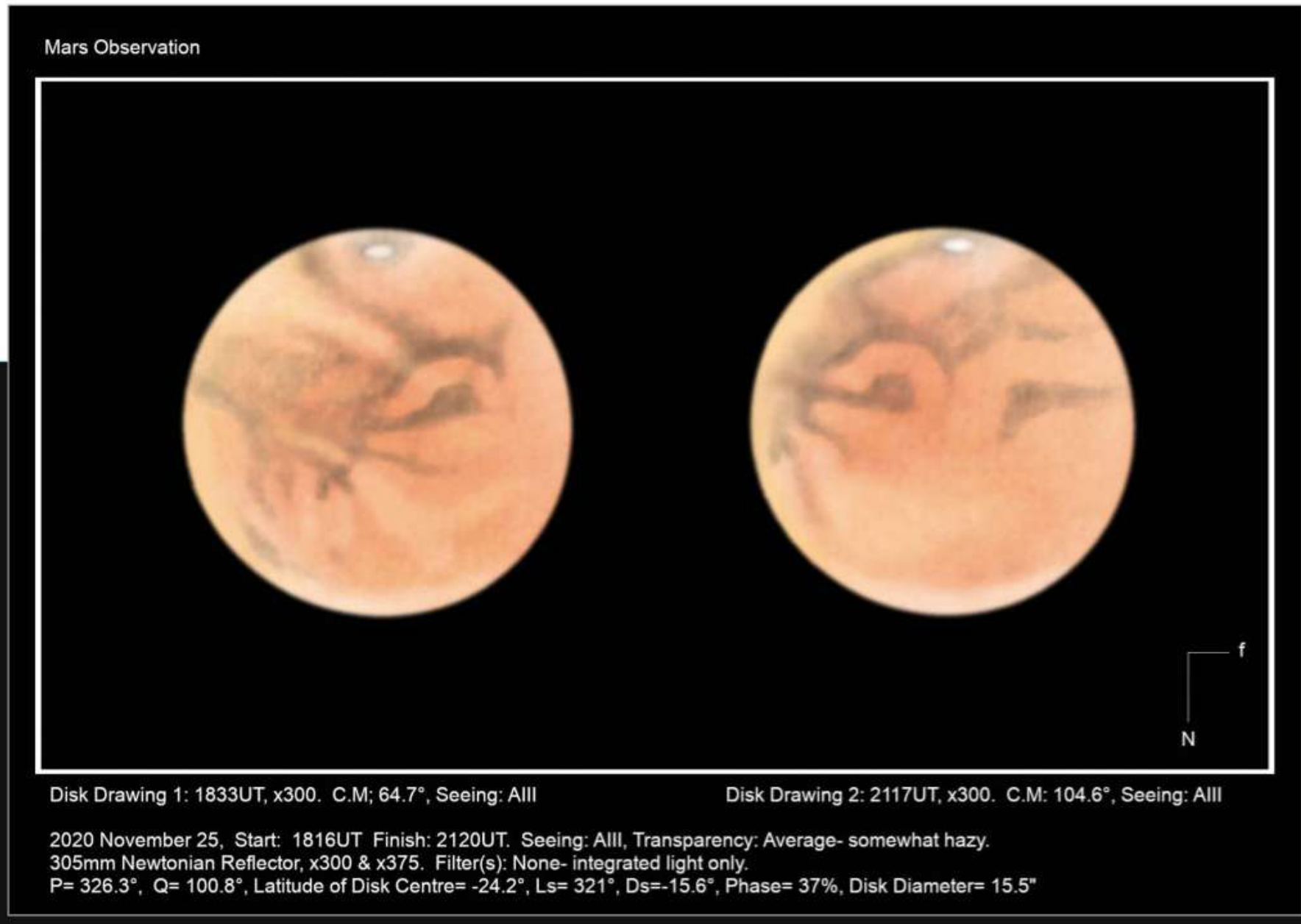
and Eridania. The large volcanoes in the Tharsis plateau also attract them, and here they can form distinctive 'W'-shaped cloud patterns.

Bright clouds and dust storms

White clouds can become quite brilliant and it is fascinating to watch them, particularly if they are close to the morning limb, as they often melt away during the course of a Martian sunrise. If you use optical filters, try a blue or violet filter as these will make the clouds stand out.

By early October, Ls is about 315° and there's a chance a dust storm might erupt. These begin life as small orange clouds but can grow to obscure whole regions or a whole hemisphere. When large dust storms occur, they throw vast quantities of dust into the atmosphere. When the dust settles, often features appear altered, which is why Mars maps from the 1950s look different to today's. Dust storms can start anywhere, but usually in the south. Watch out for small orange clouds in the basins of Hellas, Noachis and Argyre. Syrtis Major and Solis Lacus are also good places to search.

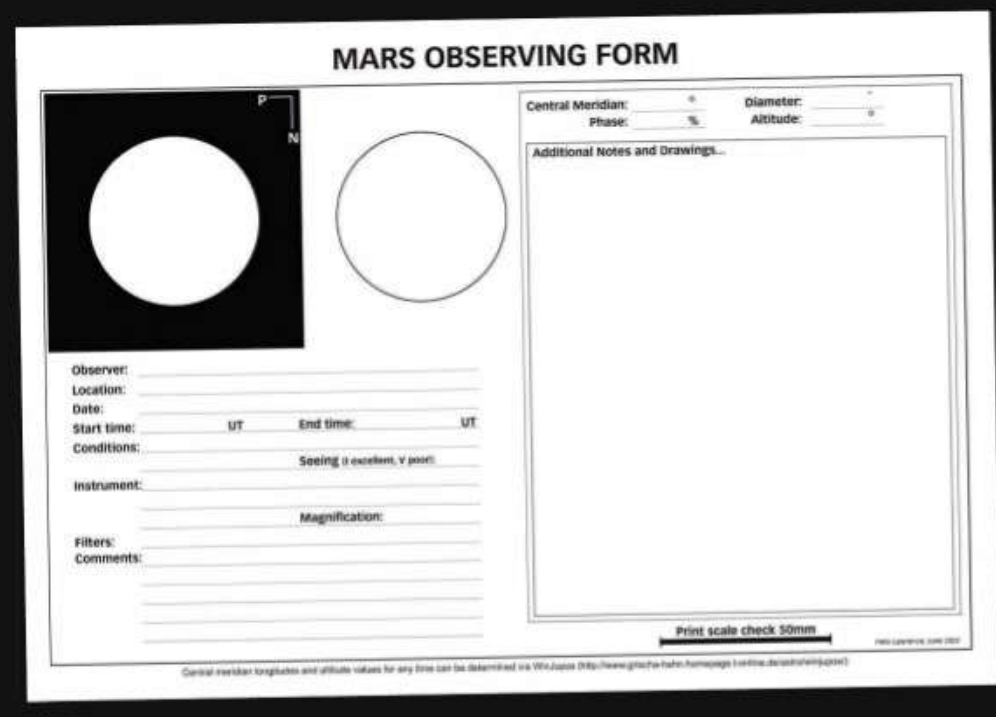
By November, Ls is about 330° and we are entering month 12. It's late autumn in the south and getting colder: watch out for frosts and fog appearing in ▸


Mars Observation
f
N
Disk Drawing 1: 1833UT, x300. C.M; 64.7°, Seeing: AIII
Disk Drawing 2: 2117UT, x300. C.M: 104.6°, Seeing: AIII
2020 November 25, Start: 1816UT Finish: 2120UT. Seeing: AIII, Transparency: Average- somewhat hazy.
305mm Newtonian Reflector, x300 & x375. Filter(s): None- integrated light only.
P= 326.3°, Q= 100.8°, Latitude of Disk Centre= -24.2°, Ls= 321°, Ds=-15.6°, Phase= 37%, Disk Diameter= 15.5"

Sketch what you see

▲ One of the author's sketches of a dust storm over Argyre Planitia, along with detailed notes of the observation

It's simple and a great way to fine-tune your Martian geography know-how



◄ You can find a blank sketching/ observing form to start recording your Mars observations in our Bonus Content section online

Start sketching the Red Planet long before opposition and it won't be long before you have drawings of the entire surface. Follow these five simple steps:

1. First, you'll need to make a blank to draw on. Download yours in this month's Bonus Content (see page 5) or make your own by drawing a white circle 50mm in diameter.

2. Spend a good 15 minutes observing Mars at your telescope before starting. What details are visible? Can you see a polar cap? Are there any prominent dark markings? What else can you see? Experiment with magnification so that the features are not too blurred.

3. You're ready to draw. Start by putting in the terminator. Near opposition, Mars is 100 per cent illuminated, but either side of opposition, the planet has a phase. The terminator is not necessarily at right angles to the central meridian, so draw it carefully.

4. Now add the most prominent dark features, then the polar cap if you can see it. Add subtle features like clouds or delicate streaks. The Martian limb may be quite bright if clouds are present. Complete your drawing within 12 minutes: any longer and Mars's rotation will have significantly moved the features.

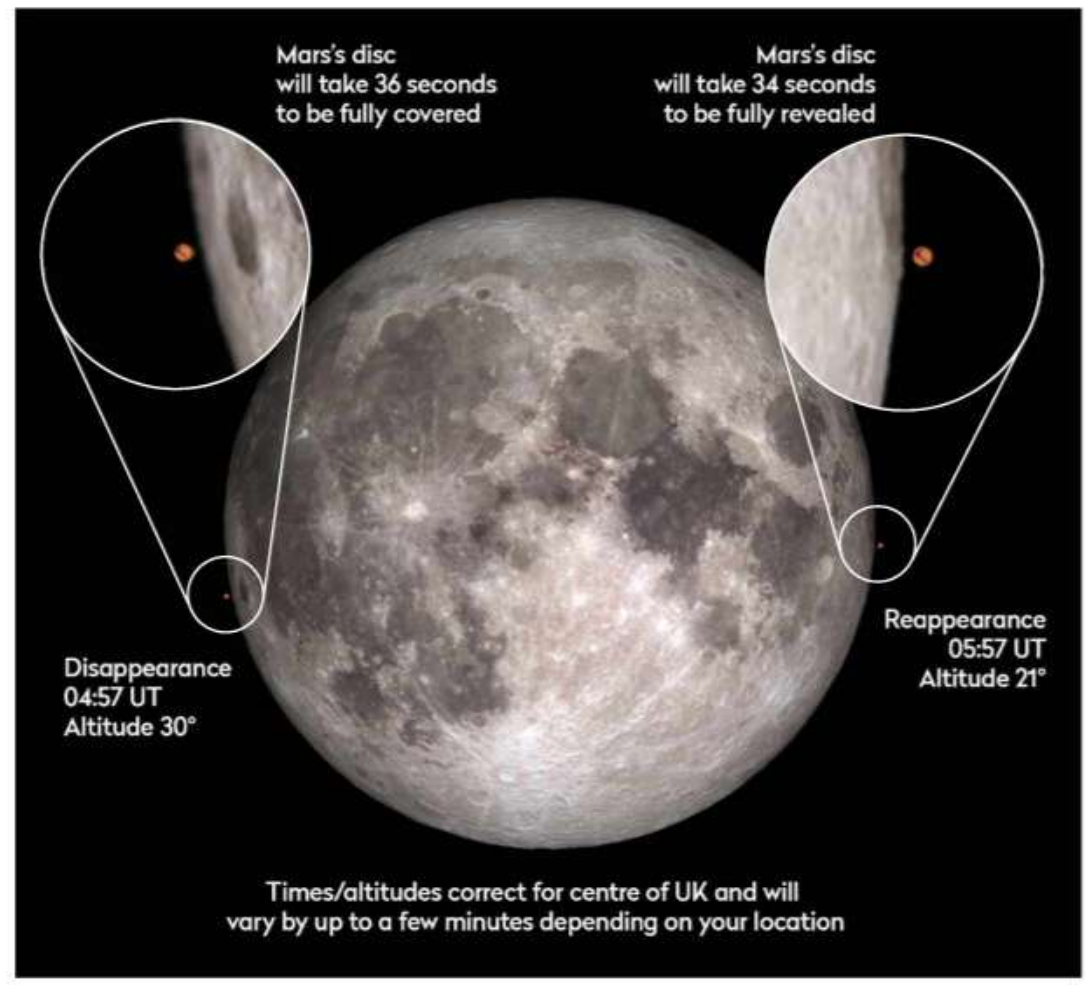
5. Finally, record the date, time (in UT) and telescope size and details. You can add other data like the value of the central meridian: this tells you which feature is on the north–south line at the time of your drawing.

Now try this

Once you're comfortable sketching the Martian surface, you can go on to experiment with using different colour filters. Blue enhances white clouds, orange/red brings out any orange clouds. If your drawing was made using a filter, record that too. The more you draw Mars, the more you will see!

PAUL ABEL, CHART BY PETE LAWRENCE, RICARDO J VAZ TOLENTINO

► As a remarkable bonus treat, Mars will also be occulted by a full Moon on opposition day

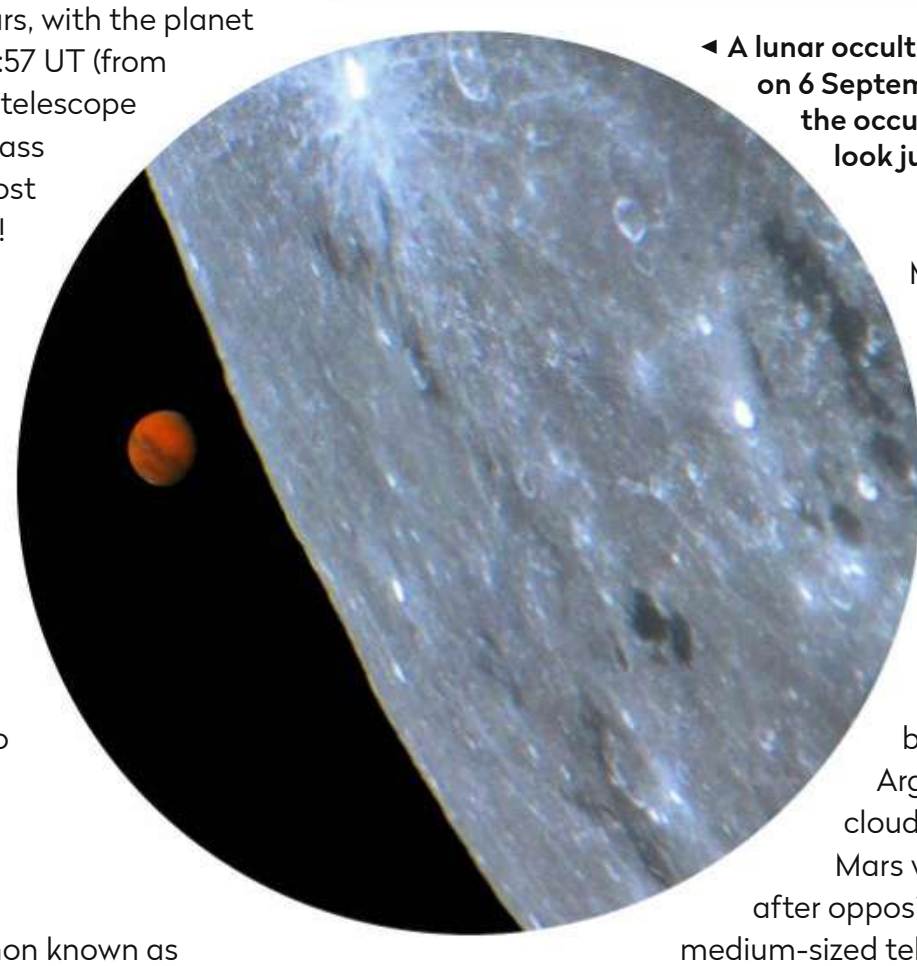


► Hellas and Argyre. There may be bright clouds over Edom and the volcanoes, while the northern polar cap should now be easier to see.

Opposition... and occultation too!

On 8 December opposition occurs and, remarkably, we can look forward to a rare lunar occultation of Mars on the same date. See it with the naked eye, binoculars or a telescope. At about 04:00 UT, look towards the west and the Moon will be close to Mars in the constellation of Taurus. Mars is predicted to be 'touching' the western limb of the Moon at about 04:57 UT, when viewed from the centre of the UK. The exact timing will depend on your location (from London it occurs around 05:00 UT; from Edinburgh at 04:52 UT), so it pays to start observing slightly earlier. The Moon will then pass over Mars, with the planet predicted to reappear around 05:57 UT (from the centre of the UK). Through a telescope you'll be able to watch the disc pass down behind the lunar limb, almost as if Mars is setting on the Moon!

Later on 8 December, turn your telescope to Mars at 19:00 UT and you will see the Solis Lacus (the eye of Mars) looking straight back at you. The north polar cap should be visible at the bottom of the disc (in a mirror-inverting telescope) and Olympus Mons will be located near the bottom right limb. If there are any bright clouds present, this huge volcano will appear quite bright even in medium-sized telescopes.



◄ A lunar occultation of Mars, taken from Brazil on 6 September 2020. Weather permitting, the occultation on 8 December should look just as spectacular

Hunting flashes

There is a fascinating phenomenon known as 'Mars flashes', brilliant 'starlike' flashes that can last for a number of seconds. They occur in two regions: Edom and Tithonius Lacus (see map, page 62), and although occasional flashes have been reported elsewhere, these are the main two sites to keep an eye on. The flashes are thought to be caused by reflections from ice crystals in clouds over these regions. The geometry has to be just right. If you were standing at these sites, Earth and the Sun would have to be overhead near the zenith.

This special alignment between the Sun, Earth and Mars is very rare, and doesn't necessarily occur at each opposition. Check our table of predicted dates and times on page 63 and see if you can detect these light signals from Mars.

Dr Paul Abel is an astrophysicist and the Director of the British Astronomical Association's Mercury and Venus section

The spring equinox in the north of Mars (Ls = 0°) starts on Christmas Day; the onset of the warmer weather (for Mars) will see the sublimation of the north polar cap – ice changing directly from a solid state into vapour, returning volatiles to the Martian atmosphere. Brilliant fogs and hazes will collect along the boundary of the northern pole, making the whole area very brilliant. Keep an eye on Hellas, Argyre and Eridania, as bright, white clouds are likely to collect around here. Mars will still be a viable target months after opposition. Owners of small- to medium-sized telescopes can follow it until the end of February 2023, with the planet remaining above 10 arcseconds. Larger telescopes will continue to show details on Mars well into April.

During January and February, Mars's tilt as seen from Earth means we will get a good look at the equatorial regions. See if you can observe the north and south polar caps at the same time. During these months it is autumn in the south and the great southern cap will be starting to form, continuing to grow until winter.

There will be lots to see on Mars over the coming months, making it a spectacular sight before and after opposition. Whether it's a large global dust storm or Martian light signals, you can chart your own telescopic adventures on the Red Planet.

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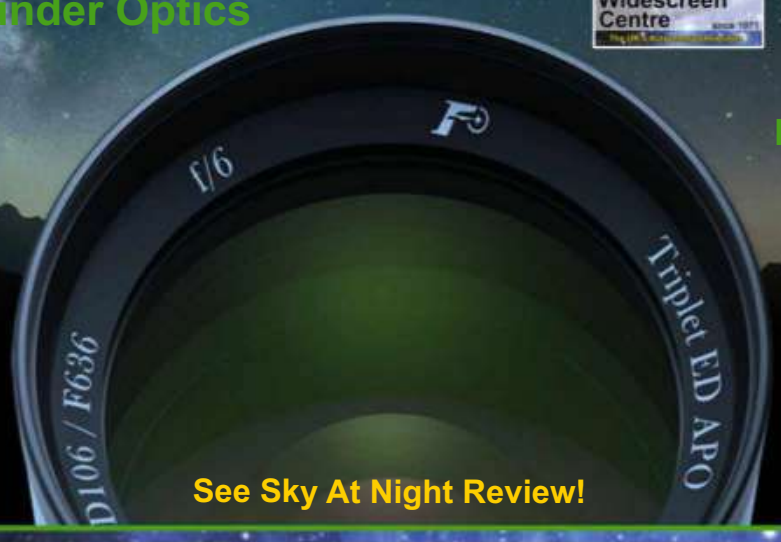

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News & Events Autumn 2022

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PART 3 OF 4

From city lights to DEEP SPACE

As the nights lengthen, **Rod Mollise** reveals rewarding objects to seek out in suburban and city skies this autumn

Autumn's arrival means the evenings are drawing in and the promise of long, dark, starry nights beckons us to get our telescopes out. As summer's jewels recede and the delights of winter make their first appearance, we are presented with a view away from the plane of the Milky Way. Galaxies are again the main attraction for observers and there are some great ones lurking in autumn skies. Autumn also offers a good selection of other objects, from star clusters to nebulae too.

The key to exploring the urban night sky is to ensure you have the tools: larger apertures will reveal more. But perseverance is also important – you will be amazed at the marvels you can discover. Let's get stuck in! ▸

'Uncle' Rod Mollise is an American amateur astronomer and writer who lives near Mobile, Alabama. He is the author of *Choosing and Using a New CAT*

JULIAN74/ISTOCK/GETTY IMAGES

There's plenty to discover even under city lights – and now longer nights to enjoy the hunt

Autumn sights

Take our tour of autumn's favourable constellations, unearthing jewels as we go

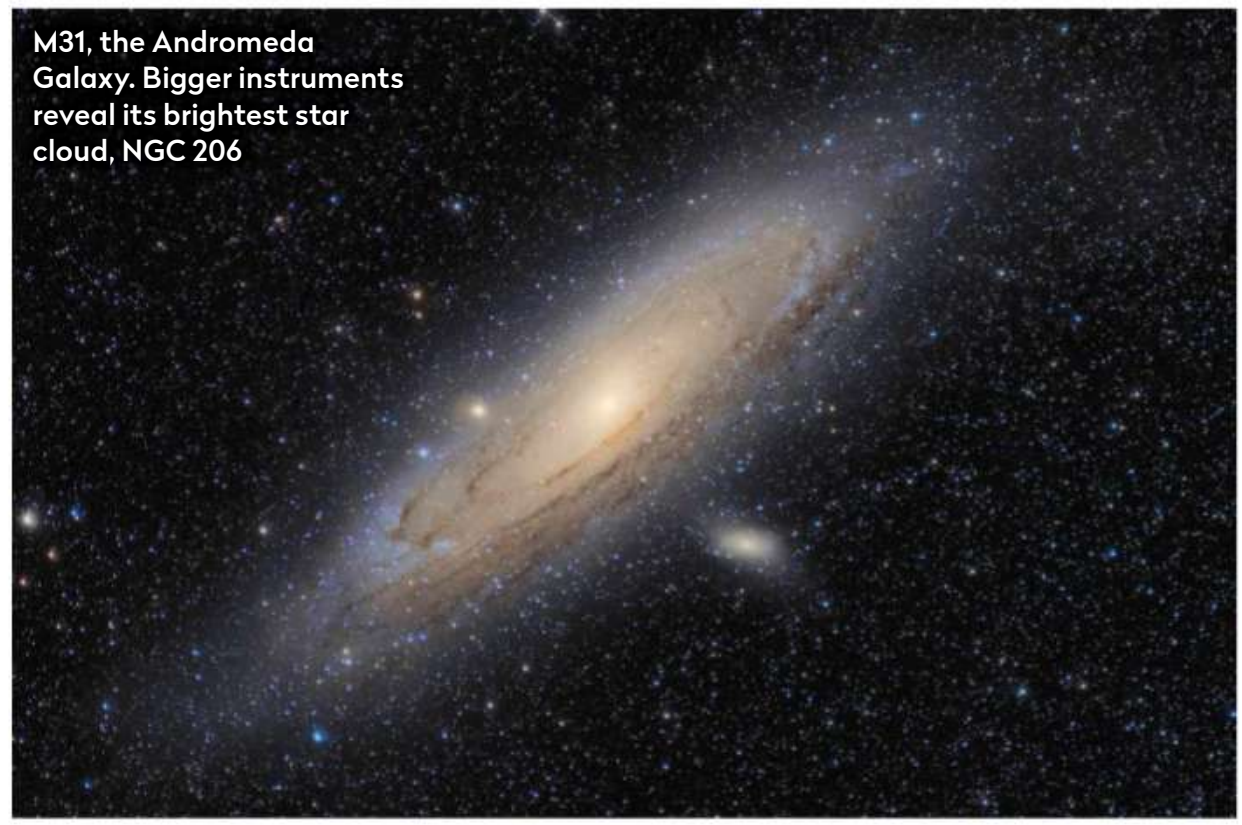
Pegasus, the Flying Horse

This well-known constellation is easy to find in the night sky

Pegasus's Great Square – three bright stars in Pegasus, one in Andromeda – is easy to spot. Extending from the Square's southwest corner is a line of stars that represents the Horse's neck and head, terminating in brilliant mag. +2.3 Enif (Epsilon (ε) Pegasi), Pegasus's nose. Just 4° northwest of this is target number one, globular star cluster **M15** (mag. +6.3, 18′ across). Although it's easy to see, resolving its stars is difficult for smaller instruments. In the city, what is visible depends on your telescope's aperture: the larger the better. The most impressive thing about M15 is its bright core. Most groups of galaxies in Pegasus are faint, but spiral galaxy **NGC 7331** (mag. +9.48, 10′10″ x 3′42″) can be seen by urban astronomers.

Andromeda, the Maiden

The famous constellation is at the northeast corner of the Great Square



M31, the Andromeda Galaxy. Bigger instruments reveal its brightest star cloud, NGC 206

M31 (mag. +3.4, 3°9′ x 1°1′) is so bright it can be seen with the naked eye, even in the city. Located 7°30′ northwest of mag. +2.0 star Mirach (Beta (β) Andromedae), M31 is so large you'll need binoculars or the widest field telescope. In the suburbs, it's possible to glimpse its spiral structure. A 12-inch or larger reflector reveals a bright star cloud near its southwestern tip: **NGC 206**, an oval, 3′-long brightening of the galaxy's nebulosity. In suburban skies, 8-to 12-inch telescopes reveal one of M31's many globular star clusters, mag. +13.8 **G1**, also known as Mayall 1.

Like the Milky Way, M31 has a number of smaller galaxies orbiting it. The brightest, **M32** (mag. +8.0, 8′30″ x 6′30″), lies 24′ south of its big sibling. It's easy to see in 3-inch refractors in the city and in 50mm binoculars from darker sites.

M31's other bright companion, **M110** (mag. +8.0, 21′54″ x 11′), is difficult to see with reflectors of 4-inch aperture, but easier to view with a 6-inch.

Finally, the outstanding planetary nebula **NGC 7662** (mag. +8.3, 20″ x 15″) is easy to see from the city, even in 3-inch refractors, if you use 200–300x magnification.

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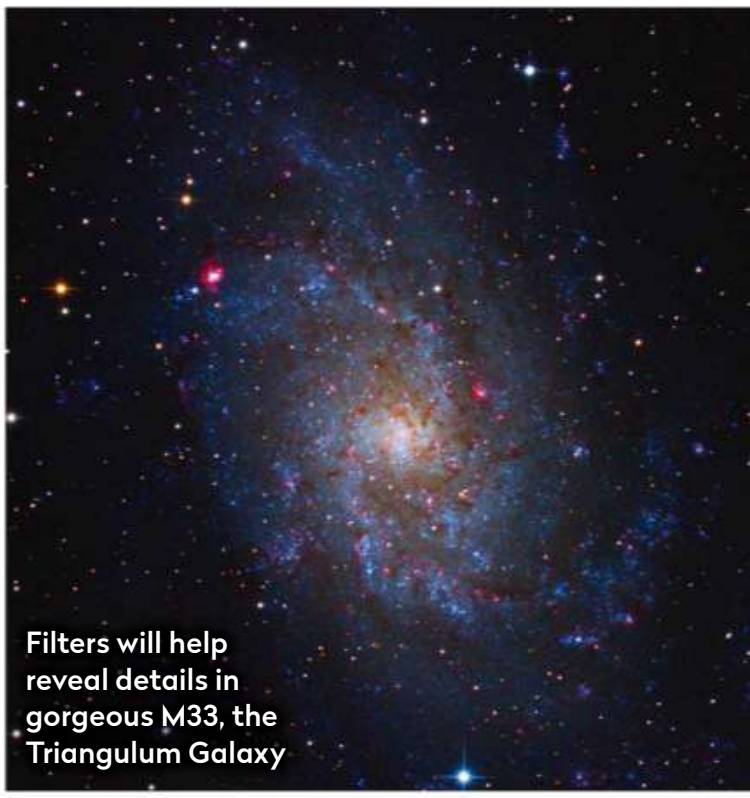
Triangulum, the Triangle

A small constellation that's home to one of the gems of the night sky

While its stick figure – a triangle of 3rd and 4th magnitude stars – doesn't stand out, Triangulum should be visible in most urban skies if you know where to look and you've allowed it to climb high in the sky. That's more than can be said for the much larger constellation it lies next to, Pisces, the Fishes. An attractive constellation from darker skies, Pisces's member stars are mostly faint, near mag. +5.0, and thus the Fishes suffers in city skies and may be completely invisible. The deep-sky objects it does contain are equally faint and difficult to realise from the city and suburbs.

Triangulum, however, contains one of the most beautiful galaxies in the sky, **M33** (mag. +5.7, 68'42" x 41'36"), the Triangulum Galaxy, with wide-open spiral arms and a near face-on orientation. But it is difficult to see in the city and any moisture in the air will make viewing the spiral arms almost impossible. A UHC-type nebula filter can help and may even reveal a small bright patch on the northeastern edge of the spiral, M33's titanic nebula **NGC 604**.



Filters will help reveal details in gorgeous M33, the Triangulum Galaxy

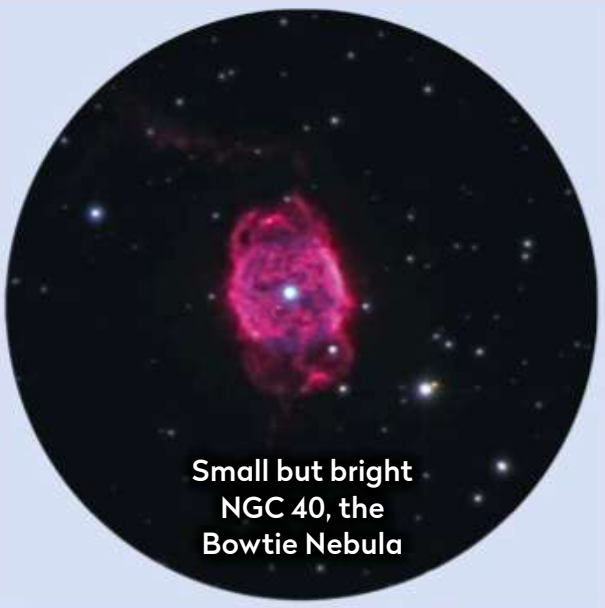
Cassiopeia, the Queen

This W-shaped constellation holds two Messier clusters

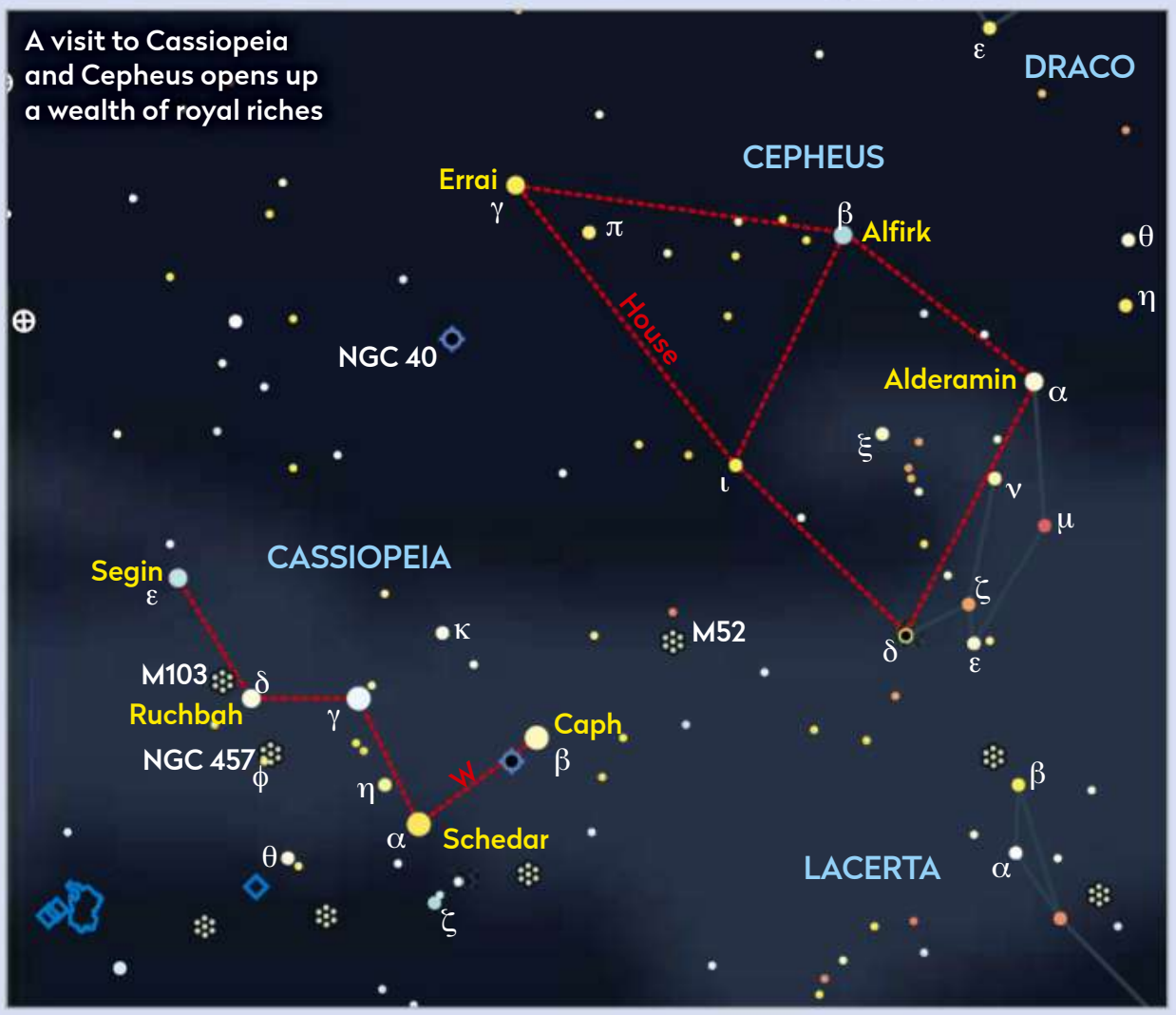
First up is an interesting cluster, **NGC 457** (mag. +6.4, 20' across). Once you have it in the eyepiece, you'll understand how it got its nickname, the ET Cluster. This medium-sized group of stars forms a little stick figure with an upraised arm that seems to be waving across the lightyears. The googly eyes, one of which is mag. +4.95 star **Phi (φ) Cassiopeiae**, do suggest a comical extraterrestrial. There is a red star in ET's right armpit that makes the cluster look even more attractive.

M103 (mag. +7.4, 6' across) has 40 stars, but expect to see up to 15 from light-polluted areas, depending on aperture. Luckily, M103's few suns, which form an equilateral triangle, are scattered across a small area, so it looks rich in the eyepiece. M103 is better from urban rather than dark sites, as out of the city the cluster melts into the star-rich background.

M52 (mag. +6.9, 16' across), west of Cassiopeia's 'W', is far better, showing as a larger, brighter and richer circle of at least 20 stars with a 3-to 4-inch refractor.



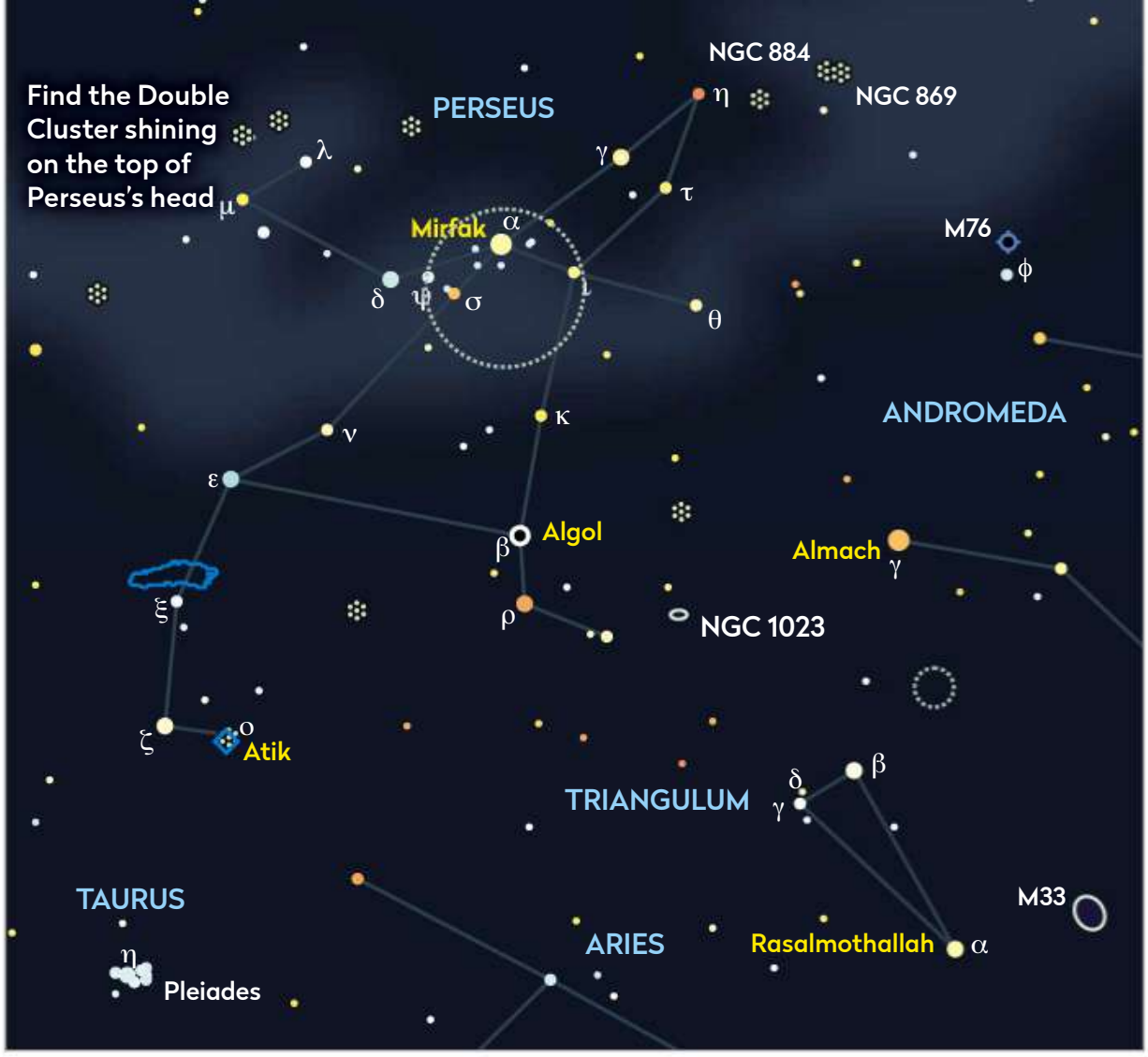
Small but bright NGC 40, the Bowtie Nebula



Cepheus, the King

Northwest of Cassiopeia lies her husband

The emission nebulae of Cepheus are a challenge for urban observers, but there is one good planetary nebula in the constellation: **NGC 40** (mag. +10.9, 37" across), the Bowtie Nebula. It's formed by two arcs of material opposite each other around the mag. +11.6 central star, which form the tie's knot. The Bowtie's magnitude sounds forbidding, but that is not a problem as it is small but bright. ▸



▲ **As one of the faintest Messier objects, M76 calls for a sizeable scope and aperture**

Perseus, the Hero

Riding high in the east and full of treasures

This constellation, which represents the hero of the Andromeda myth, is not only distinctive in urban skies, being blessed with numerous bright stars, it holds one of the most beautiful deep-sky objects in the sky.

Perseus's treasure is actually two objects, bright open star clusters **NGC 869** (mag. +3.8, 30′ across) and **NGC 884** (mag. +3.8, 30′ across). Bold in a small telescope, they sit just 25′ apart. This is the famous **Double Cluster**. NGC 869 shows 30 stars to a 2-inch refractor under most conditions, while NGC 884 looks slightly less rich and is also more noticeably elongated.

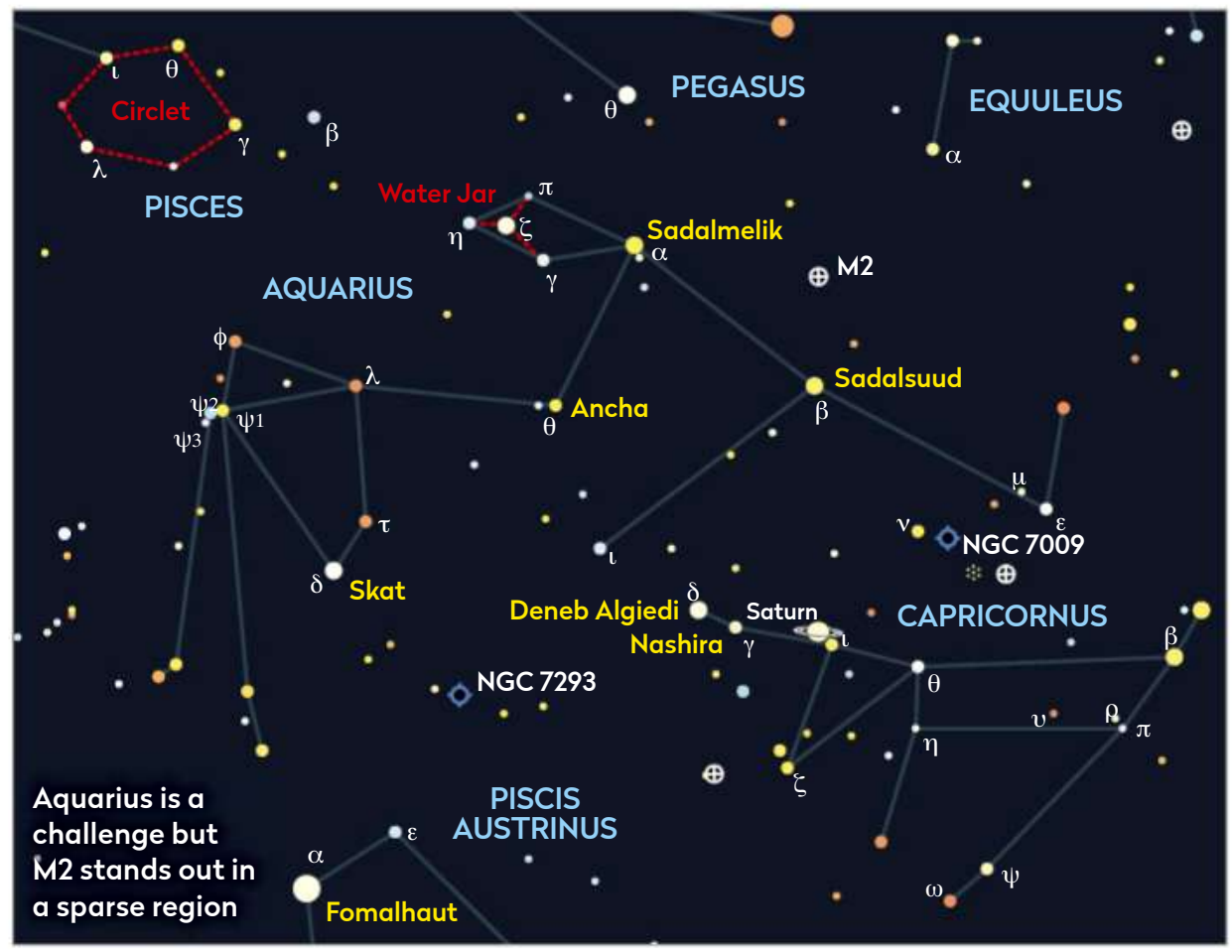
M76 (mag. +10.1, 3′7″ x 2′3″), the Little Dumbbell Nebula, isn't bright but it's not large either, so its light is concentrated. It actually looks more like a dumbbell than its more famous relative, M27, the Dumbbell Nebula. With increased aperture, say a 12-inch reflector, M76 gives up more nebulosity and begins to resemble a rectangle rather than two round spots. On the best nights, arcs of nebulosity connecting the two lobes become visible.

While the north of Perseus is a place of open clusters, the southern half is littered with galaxies. Most are beyond the range of urban astronomers with small telescopes, except for one: lenticular galaxy **NGC 1023** (mag. +10.2, 4′46″ x 2′11″) shines through heavy light pollution and is visible with a 4-inch refractor.

Aquarius, the Water Bearer

A trickier constellation with some challenging wonders to uncover

M2 (mag. +6.3, 16′ across) rivals the best globular star clusters of autumn. In the city, it takes reflectors of 10-inch aperture to resolve the many stars ringing the bright core, but even a 4-inch version provides tantalising views. **NGC 7009** (mag. +8.0, 41″ x 34″), the Saturn Nebula, was given its nickname by its discoverer Sir William Herschel in the 18th century. With enough aperture and magnification, it does look a little like Saturn when its rings are edge-on. **NGC 7293** (mag. +7.6, 25′ across), the Helix Nebula, is a great ring of nebulosity that is worth viewing. An OIII filter shows the nebula's dark centre and averted vision reveals mottling in the ring and hints of the streamers that give the Helix its name.



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Cetus, the Whale

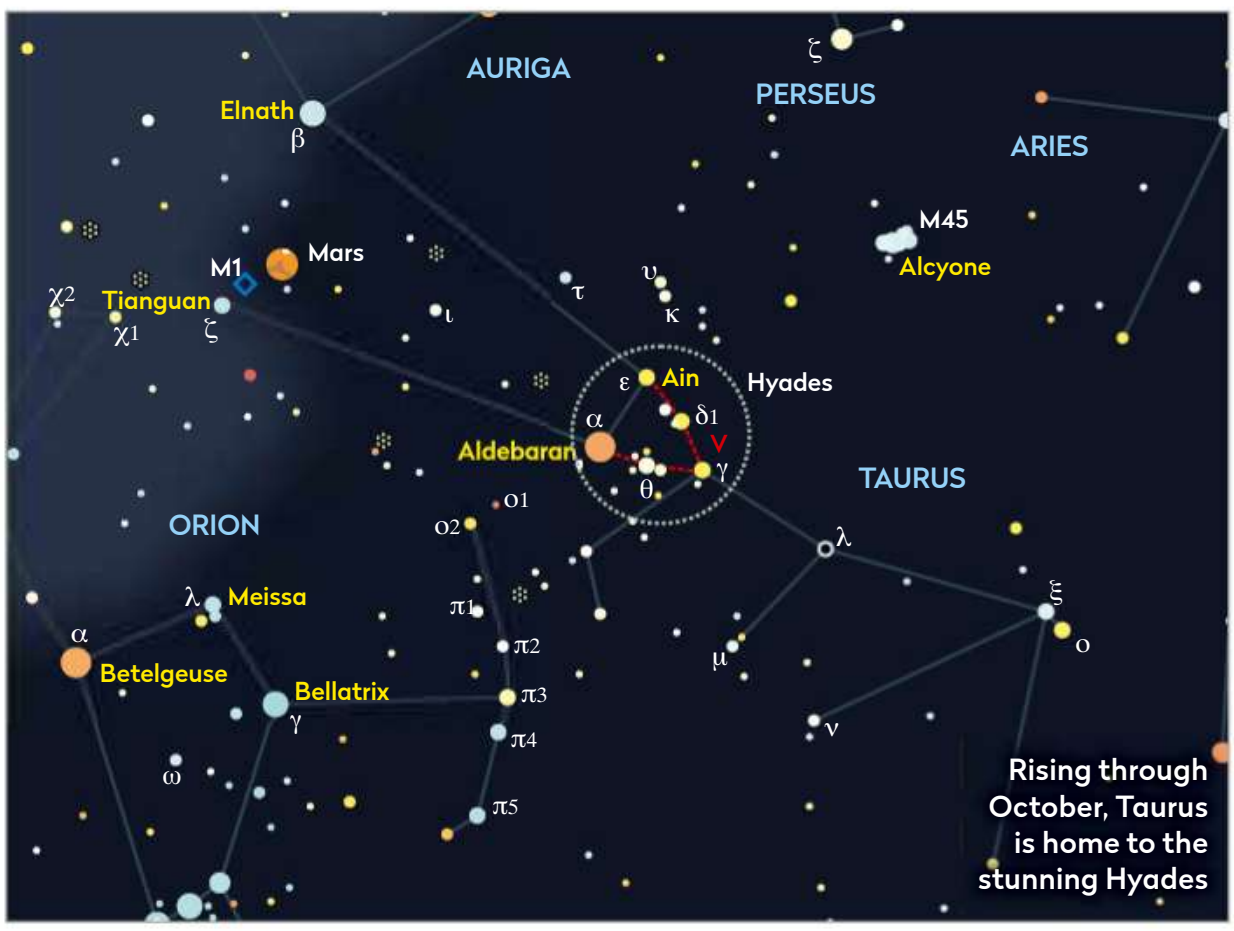
A sprawling constellation where you'll find an impressive spiral galaxy

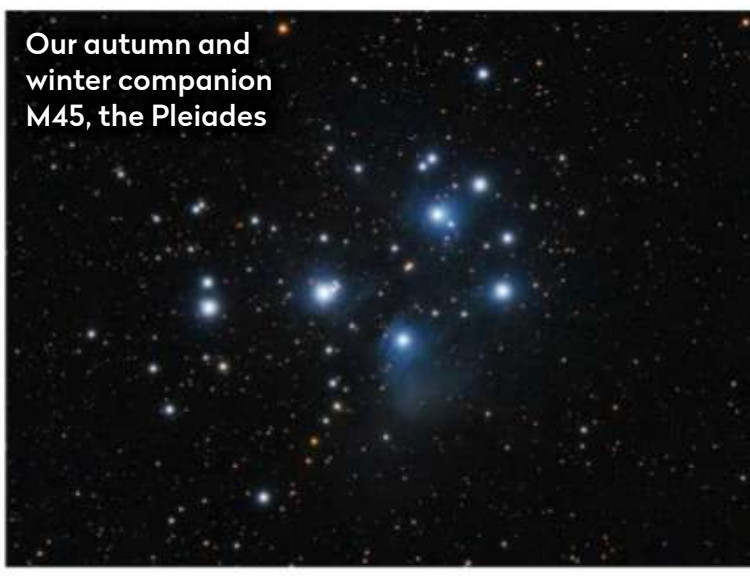
Cetus lies close to the horizon, although the area that contains **M77** (mag. +8.8, 7′ across) is slightly higher. M77 is a Seyfert galaxy, meaning it has a very bright core due to a massive black hole at its centre. In a 3- or 4-inch reflector, it shows a small, bright central region when using 100x magnification and upwards.

Capricornus, the Sea Goat

The sail-shaped constellation can be hard to see

The Sea Goat is often masked by smoke and haze near the horizon – the constellation never gets much higher than 25°. But it contains **M30** (mag. +7.7, 12′ across) which is easy to see with a 6-inch or larger refractor from badly light-polluted areas. From the suburbs, with a 12-inch refractor and 150x magnification, two streams of stars extend from the cluster, looking like the horns of a goat.





Taurus, the Bull

One of the most beautiful constellations in the night sky

The V-shaped pattern of the face of the Bull is formed from the brightest stars of an open cluster, the **Hyades** (mag. +0.5, 5°30′). It is so large because it is so close to Earth – only 151 lightyears away. The size of the group means it's best suited to small, short focal length telescopes and binoculars.

M1 (mag. +8.4, 4′ across), the Crab Nebula, was the first object to make it on to Charles Messier's list. While it is easy to find, only 1° northwest of star Beta (β) Tauri, which forms one of the corners of Auriga's pentagon, it is badly compromised by light pollution.

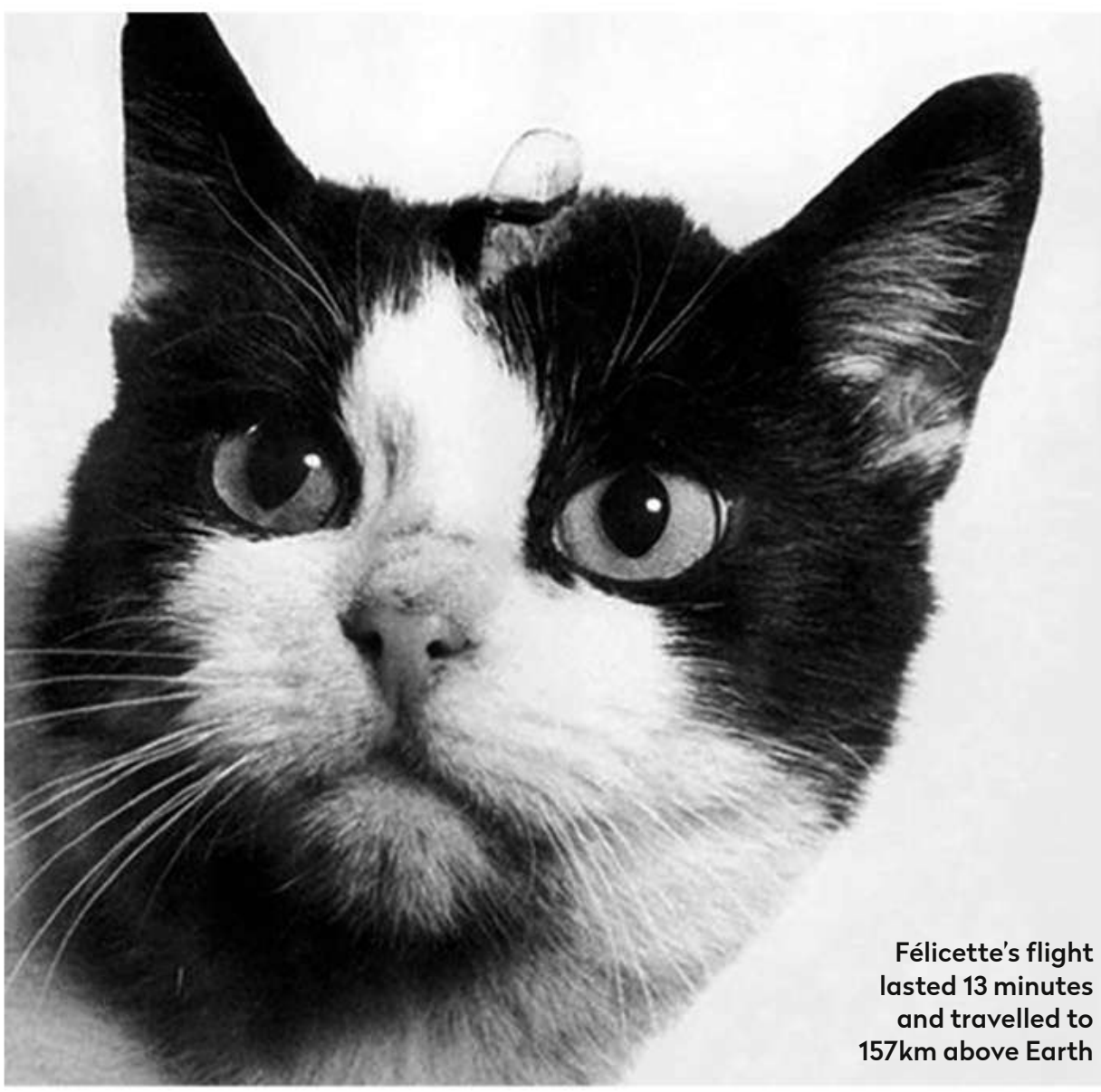
You don't need a telescope or a Go-To system to locate **M45** (mag. +1.2, 2°), the justly famous Pleiades – it is a brilliant open cluster. It can be mistaken for Ursa Minor's Little Dipper asterism; its brightest stars are arranged in a similar, vaguely dipper-like shape.

The rise of M45, the Pleiades, heralds the end of autumn and the advent of winter, and brings this part of our seasonal tour to a close.

EXPLAINER

Félicette, the cat that flew to space

Stuart Atkinson tells the story of the only feline to have survived spaceflight



Félicette's flight lasted 13 minutes and travelled to 157km above Earth

INA.FR/YOUTUBE.COM X 2, PETE LAWRENCE, MATTHEW GUY

The chances are, if you saw a crossword clue 'Animal that flew into space (3)', you'd think of Laika and write, "Dog". And it might be right, but there's another correct answer. This month is the 59th anniversary of a small, black and white cat called Félicette travelling where no feline had gone before – or has gone since. But why is Félicette overlooked when Laika is so loved? Perhaps because her rocket looked like a firework compared to Laika's powerful booster. Or maybe it's because she only flew to the edge of space, on the same kind of suborbital flight that billionaires now pay a fortune for.

Félicette's story began in 1961 when, following the superpowers' successful animal flights, France decided to stage a series of missions of its own, using cats instead of dogs or monkeys, hoping to collect data that would allow them to launch their own astronauts later.

Fourteen female cats were subsequently acquired by French CERMA space scientists. To prevent the scientists from becoming attached to them, the cats were given numbers instead of names. They were also fitted with electrodes to record their brain activity.

The cats underwent 'astronaut training'. To test their reaction to being confined, they were put into small containers for long periods. They were also spun around in a centrifuge, simulating the G-forces of lift-off and re-entry. For the cat astronaut candidates, the phrase 'not enough room to swing a cat' did not apply.

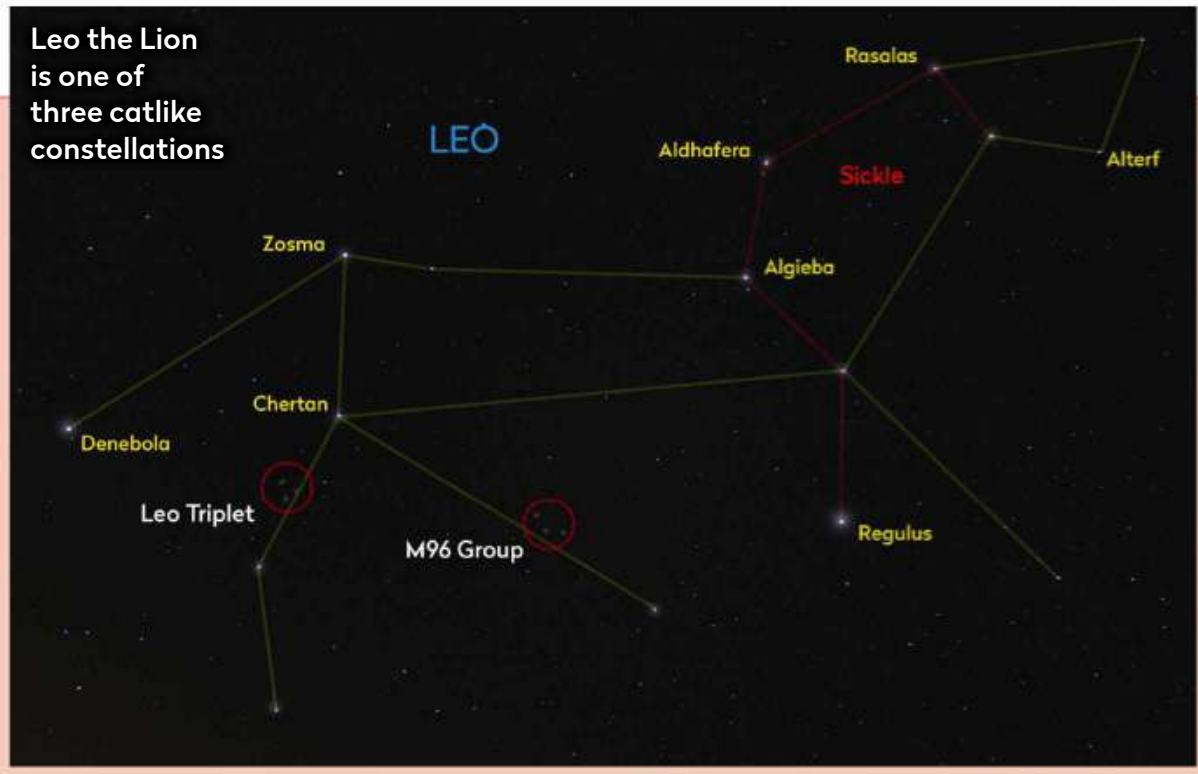
Eventually six cats were chosen to go through to the next stage, including a tuxedo cat known then only as 'C341'.

Laika flew into orbit atop a tall, chunky Sputnik rocket very similar to the Vostok booster that would carry Yuri Gagarin. But with its tail fins and pointed nose, C341's slim Veronique AGI booster looked more like a child's drawing of a rocket. It didn't even use a conventional launch tower. Instead, its weight was supported by a quartet of long fins, like the legs of a Christmas tree stand.

Launch day

On 18 October 1963, just after 8am local time, the Veronique rocket blasted off from the Interarmy Special Vehicles Test Centre in the middle of the Sahara Desert in Algeria. Coccooned inside her capsule, little C341 experienced 9.5 g, almost double the g-force the Apollo astronauts experienced as they launched to the Moon. After reaching an altitude of 157km, C341 was only 'in space' for around five minutes. Inside her capsule she had no view of the Earth.

As the rocket began its descent, the capsule separated from the booster. C341 experienced 'only' 7 g as she fell, until her capsule's parachutes opened. Thirteen minutes after lift-off the cone-shaped capsule landed, leaving C341 hanging upside down with her bottom sticking up in the air – a very undignified pose for any cat – until a helicopter arrived and she was retrieved.



Leo the Lion is one of three catlike constellations

Feline constellations

Félicette may be the only cat to have flown to space, but there are other felines that feature in the night sky

Leo This sprawling zodiacal constellation shines low in the east before dawn this month. It contains the Sickle asterism and hundreds of galaxies, including the famous Leo Triplet.

Leo Minor Prowling between Leo and Ursa Major, this small, faint, Messier-object-free constellation contains the famous deep-sky oddity Hanny's Voorwerp, a 'quasar ionisation echo' spotted in 2007 by citizen scientist Hanny van Arkel during the very first Galaxy Zoo project.

Lynx This starry zig-zag between Ursa Major and Auriga was introduced in the late 17th century by Johannes Hevelius, who thought it was so faint it took the eyesight of a lynx to see it. Five of its stars are known to have exoplanets orbiting them.

Felis Created by French astronomer and cat lover Jérôme Lalande in 1799, who felt it was wrong there were no domestic cats represented in the night sky, Felis purred between the constellations of Antlia and Hydra. It was absorbed into its neighbours and no longer exists.

▲ **Félicette is strapped into a launch seat to be loaded into the Veronique rocket**

▲ **The frame is fed into a windowless compartment the size of a large tin can**

▲ **The French Veronique AGI rocket was much smaller than any from the Apollo era**

▲ **British cat fan Matthew Guy launched a successful Kickstarter campaign to honour Félicette with her own bronze statue**

With C341 safely back on Earth it was time for France to let the world know about her flight – and finally she had a name too. In the absence of an actual name, the French media nicknamed the space cat Felix, after the naughty black and white cartoon cat from movies and television. But C341 was female, so CERMA took the nickname and changed it to the feminine version: Félicette.

Sadly, like Laika's, Félicette's story did not have a happy ending. Two months after landing she was euthanised so the scientists could carry out a postmortem to see how her body had been affected by her flight. They later admitted they learned nothing useful from the autopsy. No more cats flew into space, and France never launched its own astronauts.

But although her story is less well-known than Laika's, Félicette hasn't been completely forgotten: in 2019 a lovely statue of her was unveiled at the International Space University Campus in Strasbourg. This October, perhaps you could take a moment to look up at the night sky and think of her too.

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books, including *Félicette, the Space Cat*, available on Kindle

Create a 24-hour polar star trail photo

Merge a series of photos to make a spectacular image showing Earth's rotation

The final merged picture made from a year's worth of images

Star trails are relatively simple to do yet produce very striking results, especially when centred around the north or south celestial poles. These images capture the movement of Earth as it rotates on its axis, producing star trails that are comprised of fragments of concentric rings.

If you are in the polar regions during the winter and have clear, dark skies for 24 hours, the trails will form complete circles, including the pole star Polaris because it is not perfectly aligned with the celestial pole. Most of us will never experience a polar winter, but it is still possible to create a 24-hour star trail photograph by merging together a stack of many images taken with the same setup, from exactly the same spot, on different nights throughout the year.

Although taking a star trail image on a single night is straightforward, replicating it exactly on multiple dates, then merging them together successfully, is the challenge here. First, the camera location must be identical. We placed marks on the ground to ensure the tripod was in exactly the same spot, but attaching the camera to a fixed structure would be even better. Focus must also be the same, otherwise the width of the star trails will differ, and they won't line up perfectly. Circumpolar star trails can be created under moonlight, but doing so will affect the fainter stars, so try to ensure the Moon's brightness – its phase – is consistent between sessions. Also, when you blend your final stacked images, the overlapping regions will be brighter, so only stack what's necessary to complete the full circle.

Mary McIntyre is an outreach astronomer and teacher of astrophotography

Pick your foreground wisely

Another consideration is the foreground. It's important to have something in the foreground for context and scale. I had a large tree in mine, which grew during the year and then required an extra layer-masking step at the end to compensate for the different tree size. You might want to opt for a non-organic foreground object!

Choose some potential imaging dates that are spread across the whole year and if you have a clear sky forecast, be ready on those nights. I took images on seven nights during the year, but only used the photos taken in February, April, July and November. During the winter months you will have many more hours of imaging available to you, but in the summer you need to grab every minute of darkness.

If thin cloud moves through your field of view, don't worry; the stars will still shine through. Issues such as aircraft lights can be omitted from the image stack by using a program called StarStaX, which can fill the gaps. Before you attempt to merge the stacked images, adjust the brightness and colour balance to make them as similar to each other as possible. You may also have to apply a lens distortion correction to successfully line up the images. But all this effort is well worth it for the end result.

What you'll need

- A DSLR camera with a widefield lens and a high-power battery or mains power lead.
- A remote shutter release cable that locks in place.
- A sturdy tripod.
- A dew heater to prevent the lens from fogging up during long imaging sessions.
- Software for image stacking and processing, eg StarStaX for stacking, and Photoshop or GIMP for merging and processing the stacked images.

ALL PICTURES: MARY MCINTYRE

Step by step

Step 1

Position your tripod then mark the ground where your tripod legs lie. We used acrylic paint because it's weatherproof but can be removed with a kitchen scouring pad and water. Alternatively, screw the tripod shoe to a wall or sturdy object.

Step 2

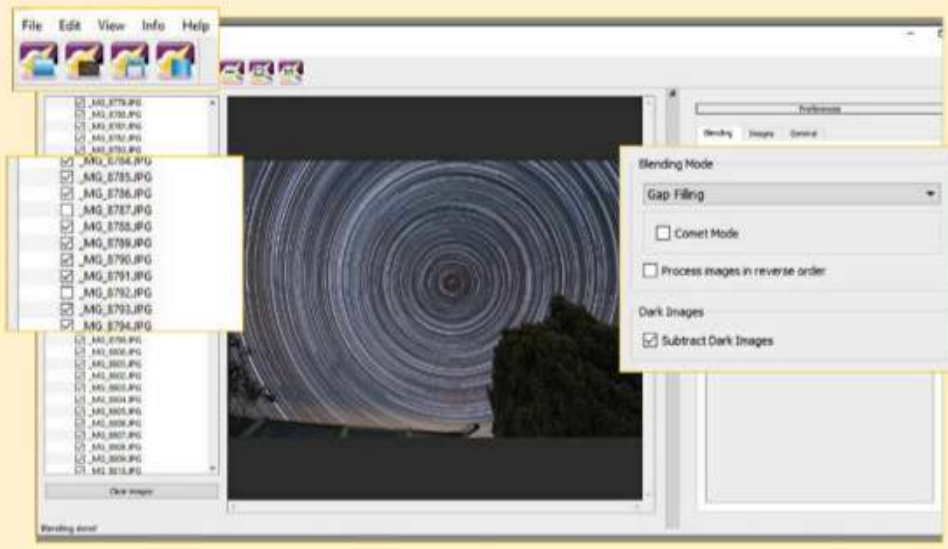
Fit the camera lens with a dew heater. Set the lens to manual focus, then focus the camera on a bright star or planet using the live view and 10x zoom. It's vital to get good focus for each session, so don't rush this step.

Step 3

Point the camera, with the celestial pole in exactly the same place in the frame for each session. Set the camera to continuous mode, shutter speed to 30 seconds, ISO to 800 and aperture to f/3.5. Lock the remote shutter cable so it takes a sequence.

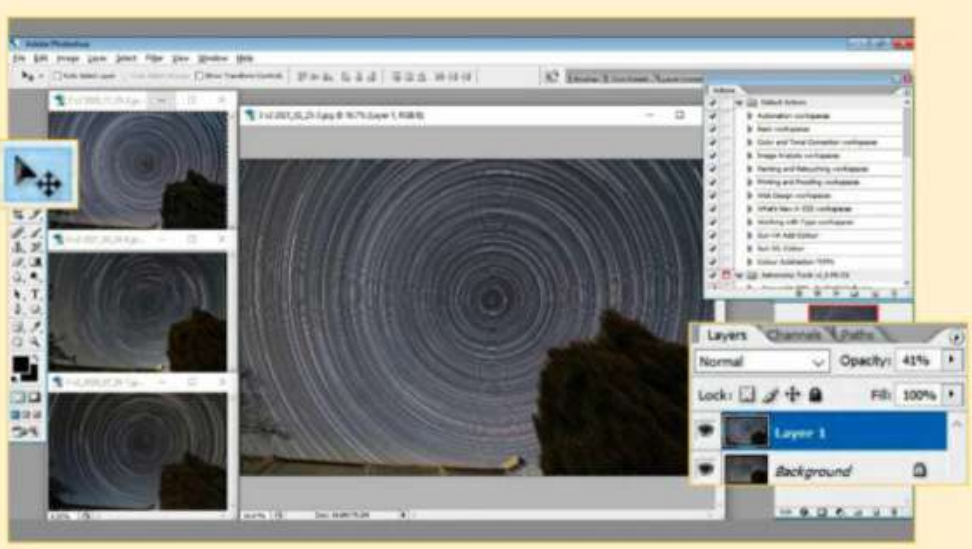
Step 4

After each session, put the lens cap on then shoot 20 to 30 dark frames. This will help to remove dark signal noise and hot or cold pixels from your images in processing. Repeat Steps 2 and 3 during different months throughout the year.



Step 5

Stack each night's data separately. Open StarStaX, drag and drop your images, then add any dark frames. Untick any images with aircraft in them. Select 'Gap filling' mode and, if needed, tick the 'Subtract dark frames' box. Click 'Stack', then save the image.



Step 6

In Photoshop, paste each session's image as a layer on top of another. For each layer, set the blend mode to 'Difference', use 'Free transform' to align, and set the blend mode back to 'Normal'. Adjust the opacity until each layer's stars have equal brightness.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

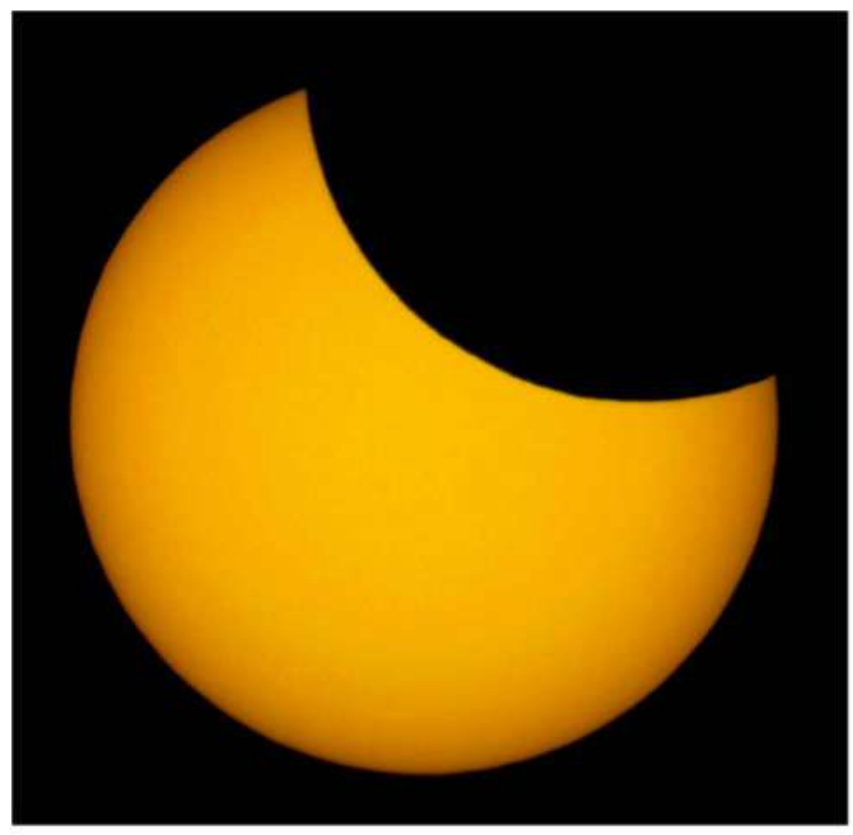
CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Image the partial solar eclipse

How to safely capture the Moon crossing the Sun on 25 October

The Moon will pass in front of a part of the Sun on the morning of 25 October, an event that will result in a partial solar eclipse. Partial solar eclipses, as their name suggests, don't cover the Sun's disc completely. As the greatest coverage will only be 24.5 per cent at best from mainland UK, the area of Sun that remains visible will pose a danger to eyesight and equipment. Consequently, great care needs to be taken to protect both. Here we'll look at some of the ways you can image the event safely.

A partial solar eclipse lacks the majesty of a total eclipse. The effects that people spend thousands of pounds on chasing to remote parts of the world are absent during a partial. Although it does have additional interest, the same is largely true for an annular eclipse, where the Moon moves in front of the Sun but its apparent size is too small to block the Sun's light entirely. A layperson unaware that such an event was taking place probably wouldn't even give it a second thought.



▲ **A partial solar eclipse makes for a great photographic event as long as you put safety first**

Getting the edge

Although there aren't many 'special effects' during a partial solar eclipse, there are still things to look out for. First contact is always exciting, noticing the first intrusion of the Moon in front of the Moon's disc being strangely satisfying. You may also have access to H-alpha filters, which can expand the experience. With an H-alpha filter it's possible to see the edge of the Moon move in front of what's known as the spicule layer, essentially the appearance of the chromosphere seen sideways-on at the edge of the Sun. Made up of many plasma jets, each around 10,000km in length, the tightly packed spicules create an edge to the H-alpha Sun that looks, for want of a better term, furry.

The Moon's passage across the spicule layer will be brief, the layer appearing very narrow against the large apparent diameter of the Sun's main disc. However, the Holy Grail would be if there was a well-positioned, well-timed prominence on show. Seeing the Moon pass across this would really give H-alpha setups an extra spectacle.

But what if you don't have an exotic and, let's face it, expensive H-alpha filter to hand? Low-tech solutions exist too, thanks to the fact that the Sun's so bright. A piece of card with a 1–2mm hole in the centre will cast a shadow with an image of the Sun projected by the pinhole. This image can be safely photographed with something as basic as a smartphone. For a little more pazazz, consider making a series of holes to form a familiar pattern or shape.

Natural effects occur too. Find a tree or bush with leaves on it and look at the points of sunlight that occur on the ground as the light passes through during the middle part of the eclipse – the leaves form irregular but still functional pinholes, the light cast on the ground forming a multitude of little eclipse images. We've suggested a number of ways you might like to capture the event on the page opposite. All we need now is clear skies on 25 October!

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

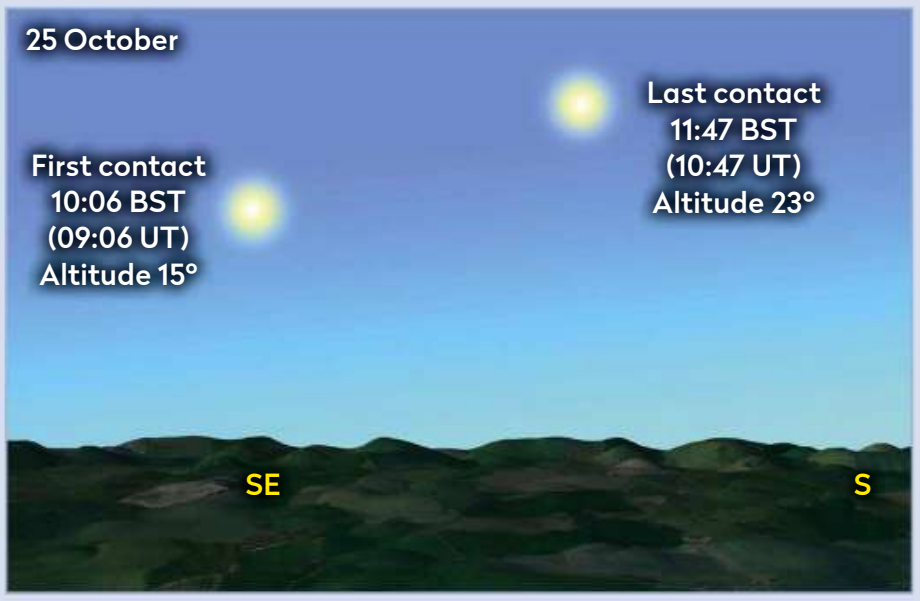
Equipment: Card, scissors, a sharp pin, telescope with a certified solar filter, camera

▸ **Read more about the partial eclipse on page 46**

Send your images to:
gallery@skyatnightmagazine.com

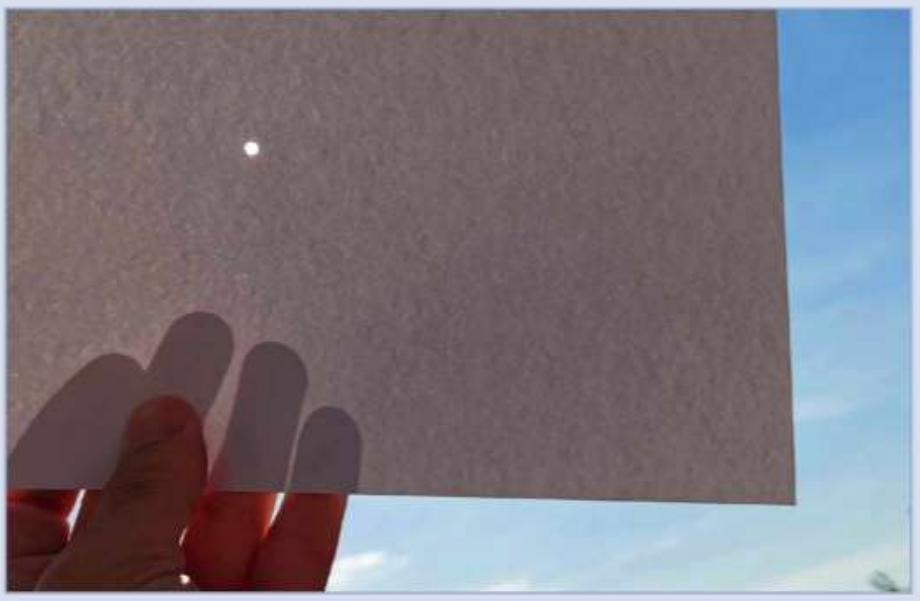
ALL PICTURES: PETE LAWRENCE

Step by step



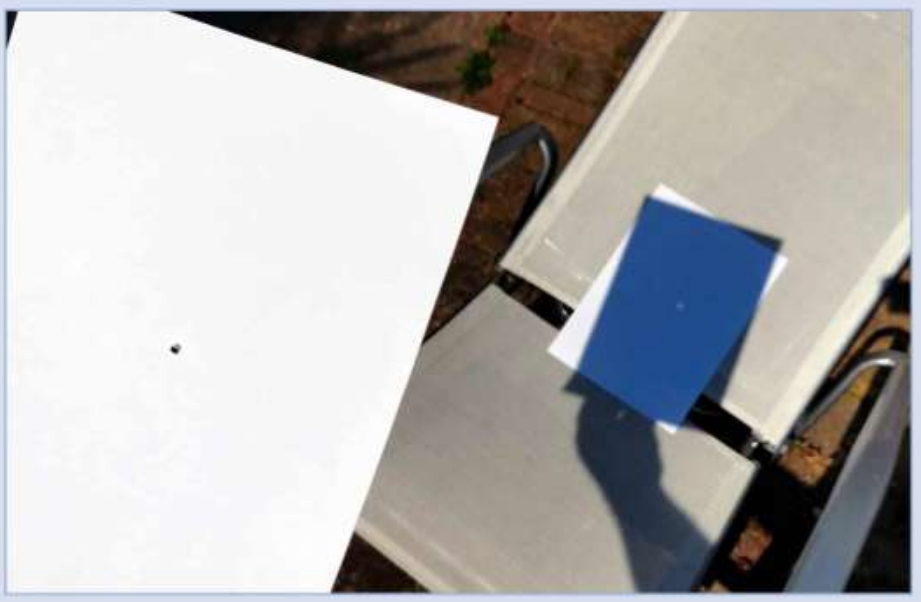
STEP 1

From the UK's centre, the eclipse begins at 10:06 BST (09:06 UT), concluding at 11:47 BST (10:47 UT). Times vary slightly depending on location. The Sun is 15° up at the start, 23° by the end. Ensure your location allows the Sun to be seen by checking visibility between the stated times on a clear day prior to the eclipse.



STEP 2

The simplest way to photograph the eclipse is to create a 1–2mm pinhole in card and project sunlight through it onto another piece of white card. The 'screen' will need to be a metre or more away from the hole to give a decent image size and mounted vertically or at right angles to incoming sunlight to reduce distortions.

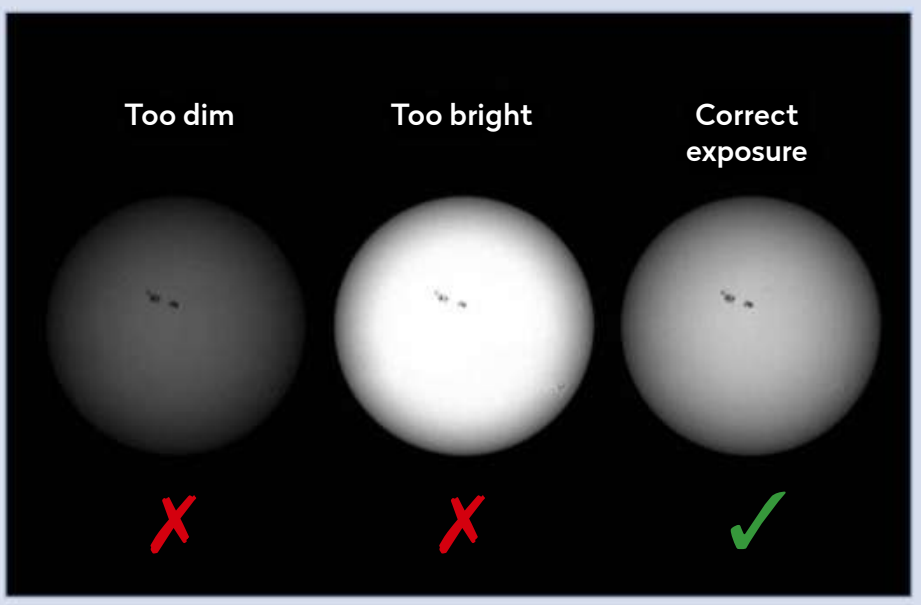


STEP 3

Hold a smartphone or camera so it can see the image created by the pinhole on the 'screen'. For automatic cameras, the image should be bright enough for auto-focus. Take the shot (another pair of hands really helps here). To be more adventurous, make several holes in the card, spelling a word or creating a shape.

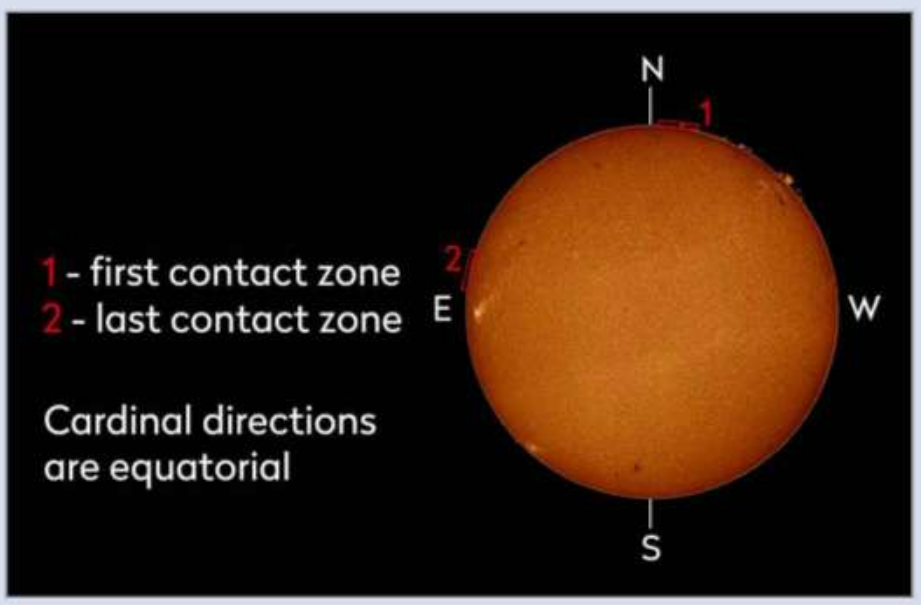
STEP 4

If using a telescope, make sure it's fitted with a suitable certified solar filter, and cap or remove any additional finderscopes. Then, 15 or more minutes before the eclipse starts, point it at the Sun using the scope's shadow on the ground or on a wall to refine the alignment. Important: don't sight by looking up along the scope!



STEP 5

Adjust the camera settings so the image isn't over-exposed. If using a white light filter and mono high-frame-rate camera, consider a green imaging filter to improve surface contrast, revealing the granular texture of the Sun's photosphere. Focus as accurately as possible either on this texture or on the Sun's limb.



STEP 6

The typical key times to capture are slightly after first contact, mid-eclipse (10:56 BST (09:56 UT)), and just before last contact. For H-alpha setups, examine the Sun's northwest and northeast limbs for prominences. Northwest features will disappear first, so be vigilant from five minutes before first contact.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Subtract stars to get more from deep-sky data

Avoid distortion while processing by taking the stars out of the picture with free software

ALL PICTURES: CHARLOTTE DANIELS

Astrophotography processing is all about the art of data control and getting the right balance between stretching data to tease out details, without going too far and 'clipping' it. Once the data is overstretched, delicate details are lost, or the image becomes noisy.

Stars are one major obstacle during processing. They limit the extent to which data can be enhanced, as they distort or become bloated. This reduces the desired 'natural' appearance for deep-sky images. Software that can remove stars therefore allows the user to work on all the delicate details, without being hindered by stars. One example is the free software StarNet++. Originally developed as a PixInsight module, it's now available as a standalone program via **www.starnetastro.com/download**. StarNet++ is compatible with both CCD and DSLR data, and so a popular choice for most astrophotographer toolkits.

Version 2 of the software was released early 2022 and includes a handy graphical user interface (GUI) that makes it more intuitive. This is the version we used to process our image of the Flaming Star Nebula (IC 405). Here we will go through the steps we took to remove the stars using StarNet++ and then use Photoshop to recover a 'stars-only' file which we could reapply to our fully processed nebula at the end.

▲ Left: The unprocessed starting image of the Flaming Star Nebula (IC 405), before the stars were removed

▲ Right: The final processed image, with the stars reinstated

Takeaway time

Our initial image (above left) was a stacked TIFF file we labelled 'Start image'. First, we opened this 'Start image' in Photoshop by clicking File > Open and navigating to our file location. We then minimised our Photoshop screen and clicked on the StarNet++ icon on our desktop. A StarNet++ GUI menu popped up (see screenshot 1, opposite right). By clicking on 'Browse', we navigated to the location of our start image and selected it.

Both the top and bottom boxes of the StarNet++ menu then filled with the file's path location. We amended the bottom box slightly: adding 'starless' next to 'Start image' (screenshot 1). This means that StarNet++ saved a separate 'starless' version of our file. We then clicked 'Run'.

3 QUICK TIPS

1. StarNet++ sometimes mistakenly removes galaxy cores. Photoshop masks can be used to recover these.

2. Don't crop before reapplying stars, because this messes up star positions. Crop either before stars are removed or as the final step.

3. Add and remove the star layer at various stages, to check in on how your image is looking.

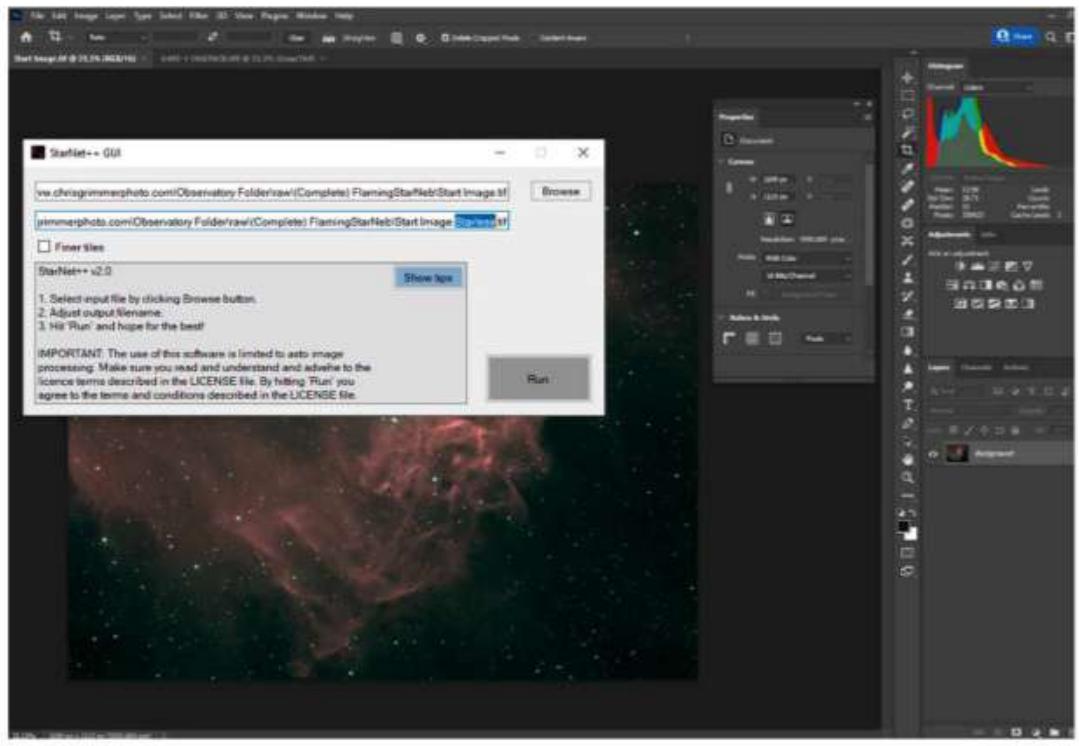
A command window called 'StarNet console' appeared, showing the progress of the star removal. 'Done!' appeared on the command window once StarNet++ had finished running. A starless version of our 'Start image', 'Start image starless' now appeared in the same file location as our 'Start image'. We opened this in Photoshop (see screenshot 2) and found the image free of all stars. This is the image we would be processing. However, before we moved on to do that, it was important that we develop a stars-only file containing just the star data minus the nebula, as we would need this at the end to reapply stars to our processed image.

To do this, we clicked back onto the original 'Start image' which was the first file we opened in Photoshop. We clicked Image > Apply Image. We then selected the starless version of our image as the 'Source' file and selected 'Subtract' from the Blending dropdown menu (see screenshot 3). This subtracted our starless file from the complete data, leaving just the stars. An image containing just the stars appeared. It is important to do this step before you process the image further.

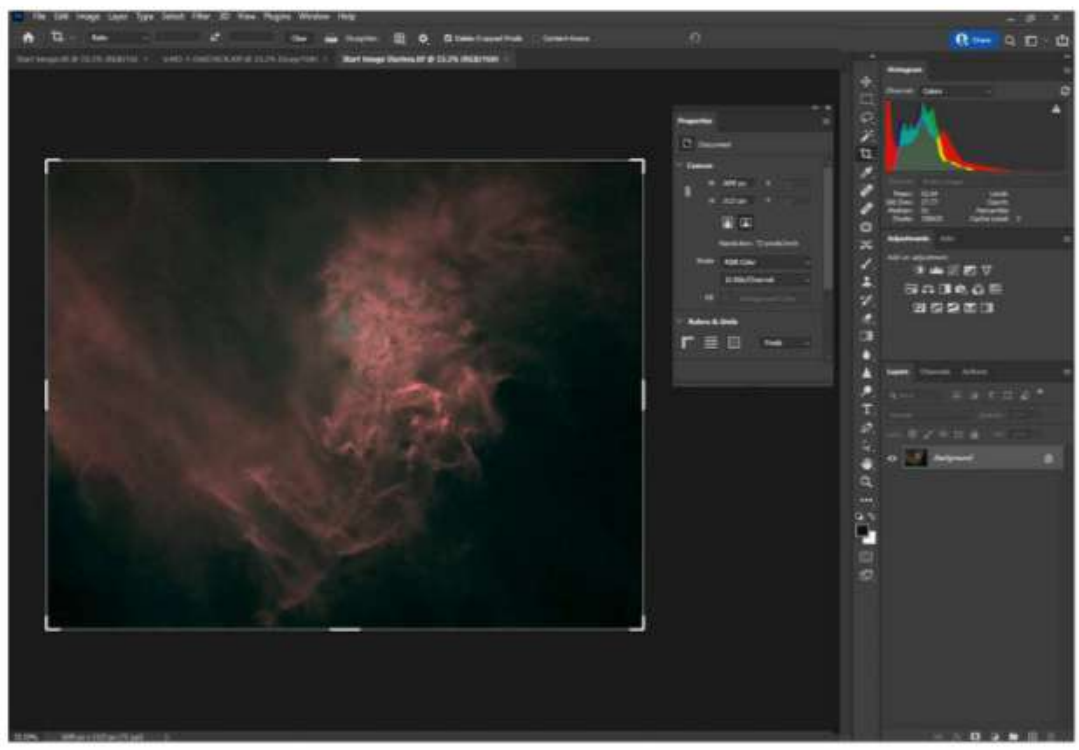
We then clicked back onto our 'Start image starless' file to process our nebula without the stars. We did this by applying Photoshop adjustments including levels, colour balance, and hue/saturation (clicking Image > Adjustments for each of these) and then adding the 'Dust and scratches' and 'Median' noise reduction filters (Filters > Noise).

Once satisfied with our nebula, we could reapply our stars. To do this, we clicked on our 'star-only' file created earlier (see screenshot 3). By clicking Edit > Select All or using Ctrl + A, the star-only image is selected. We then pressed Ctrl + C to copy the file. Clicking back onto our processed, starless image, we then pressed Ctrl + V to paste our stars as an opaque layer on top. Finally, we selected 'Screen' from the layers blending menu (highlighted in screenshot 3) to blend the starless image with the stars, creating the final image you can see on the page opposite.

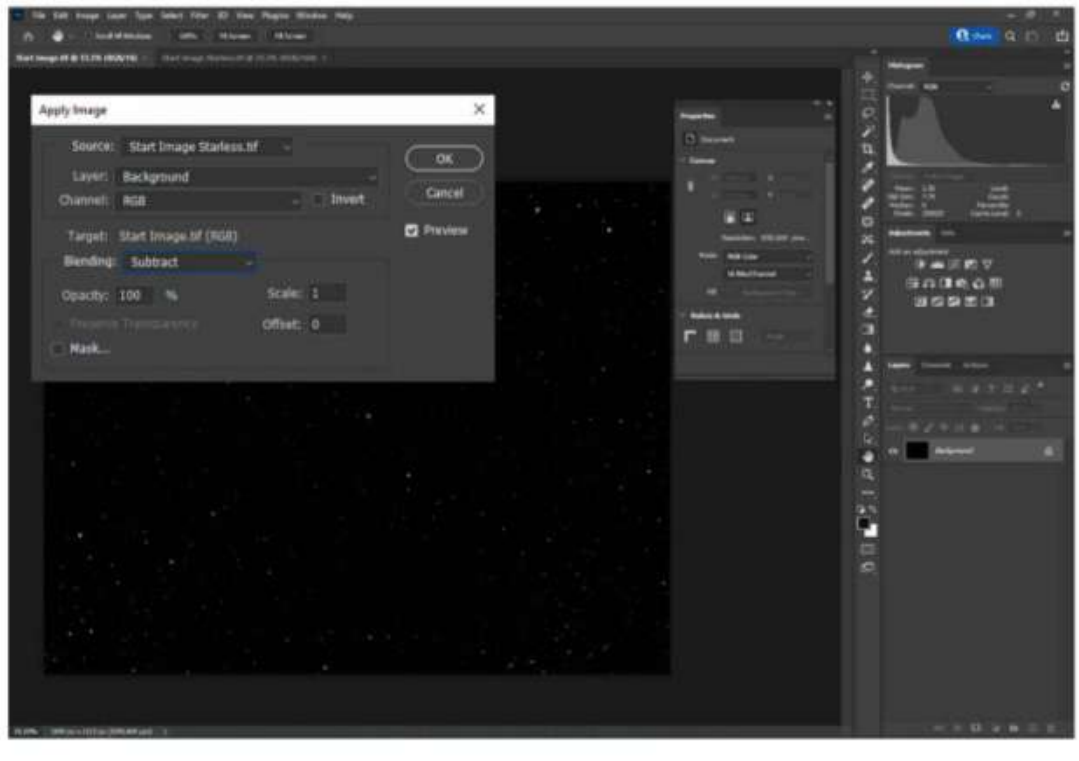
Charlotte Daniels is an amateur astronomer, astrophotographer and journalist


StarNet++ GUI
Browse
Finer tiles
StarNet++ v2.0
Show tips
1. Select input file by clicking Browse button.
2. Adjust output filename.
3. Hit 'Run' and hope for the best!
IMPORTANT: The use of this software is limited to astro image processing. Make sure you read and understand and adhere to the licence terms described in the LICENSE file. By hitting 'Run' you agree to the terms and conditions described in the LICENSE file.
Run

▲ **Screenshot 1: the StarNet++ interface. Before clicking on 'Run', 'starless' was added to the file name to distinguish the new starless nebula from the original**



▲ **Screenshot 2: Before moving on to processing the new starless version created by StarNet++, a stars-only file must be created to add in later**



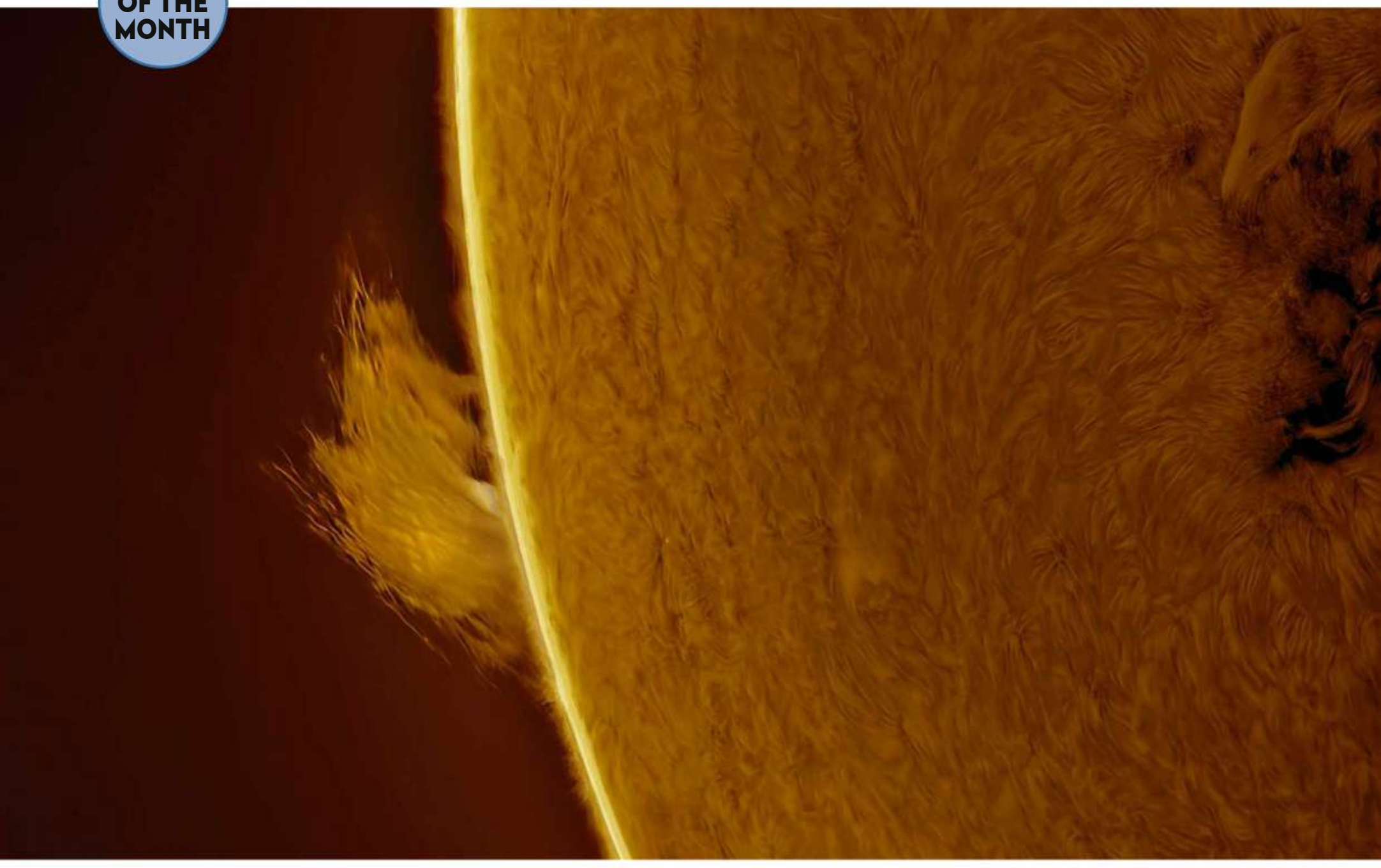
▲ **Screenshot 3: the stars-only file is copied and pasted as an opaque layer onto the now fully processed image of the nebula, before blending together**

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More **ONLINE**
A gallery containing these and more of your images

PHOTO OF THE MONTH



△ A huge solar prominence

Jay Bolt, Crigglestone, West Yorkshire, 18 July 2022

Jay says: "I had been capturing sunspots when I noticed a huge prominence forming on the Sun's limb. The seeing was unusually good early in the morning, allowing for very precise focusing and capturing of the plasma eruption. Solar activity has been steadily increasing over the last few years, and I am particularly pleased with the magnetic detail that processing has brought out on the chromosphere."

Equipment: Altair Hypercam 174M camera, Explore Scientific AR127mm refractor, Daystar Quark Chromosphere Ha eyepiece filter, Sky-Watcher EQ6-R mount
Exposure: 1,500 frames of SER format video, best 20% selected
Software: AutoStakkert!, Photoshop, Astra Image, Topaz DeNoise, Topaz Sharpen

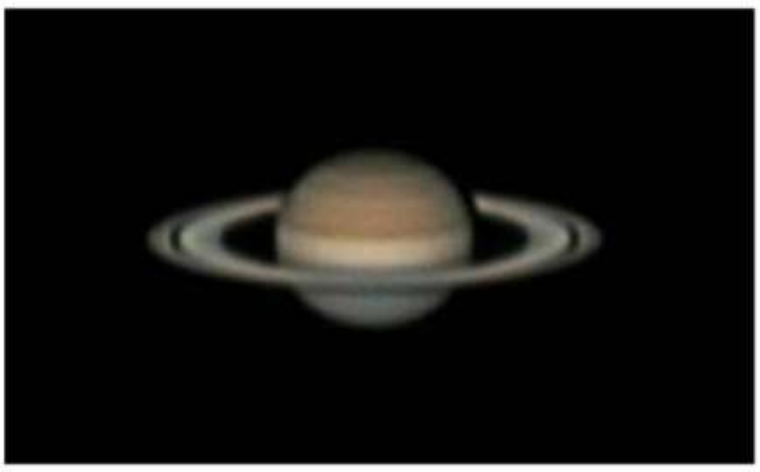
Jay's top tips: "For solar imaging using a Quark Chromosphere, aim for exposures of 5–10ms for the chromosphere to 'freeze' the effects of seeing. I use gain and the histogram to achieve exposure rates of 5ms on my Altair 174M, and take 2,000 to 3,000 exposures, with the histogram peaking around 60 per cent and taking care that the top end is not clipped. For the prominences, ignore the histogram and increase exposure to bring out the detail. Typically this is around max gain and 20ms on my camera. I then shoot for 20–25 seconds. My image is a composite: the prominences are overlaid onto the chromosphere, then colourised."

△ The Shark Nebula

Shawn Nielsen, Kitchener, Ontario, Canada, July 2022

Shawn says: "There is a lot to see in this image including LDN1235, vdB149, vdB150 and galaxy PGC 67671. The Shark Nebula is faint and requires a lot of time to really bring out the colours."

Equipment: QHY268M camera, StarField Optics 8-inch astrograph, Sky-Watcher EQ6 mount **Exposure:** 17.5h **Software:** PixInsight



△ Saturn

Padraig Connor, Belfast, 18 July 2022

Padraig says: "I took this shot of Saturn during the heatwave in mid-July when the atmosphere was calmer than usual. I manually tracked it across the sky and it was quite difficult to keep the planet centred in such a small region due to the lack of a motorised mount."

Equipment: ZWO ASI224MC camera, Sky-Watcher 200P Dobsonian **Exposure:** 3' **Software:** SharpCap, PIPP, AutoStakkert!, RegiStax

△ Supermoon over the Needles

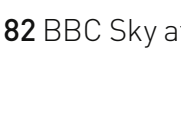
Cenk Albayrak-Touyé, Highcliffe beach, Dorset, 13 July 2022

Cenk says: "I used the PhotoPills app to work out the direction of moonrise. Right on cue, I glimpsed some orange behind the Needles. After running down the beach with my tripod to adjust the angle slightly, I managed to capture the resulting photo."

Equipment: Canon EOS RP mirrorless camera, Sigma 150–600mm lens, K&F Concept S210 tripod **Exposure:** ISO 800 f/8, 0.8" **Software:** Lightroom

△ The Moon

Sonia Turkington, North Reddish, Stockport, 10 July 2022



Sonia says: "I love imaging the Moon and have done for about 25 years. I never get tired of looking at it. I always use my smartphone, as it takes better photos than my Canon. I take a few photos until I think I've got the perfect one."

Equipment: Google Pixel 6 smartphone, Sky-Watcher Skyliner 250PX Dobsonian **Exposure:** ISO 51 f/1.9, 1/101" **Software:** Google Photos

▽ Double star Albireo

Tony Moss, Downham Market, Norfolk, 8 June 2022

Tony says: "Alberio is a favourite of mine and was nicely positioned above all the local light pollution. I wanted to see how well I could capture the colours and details."

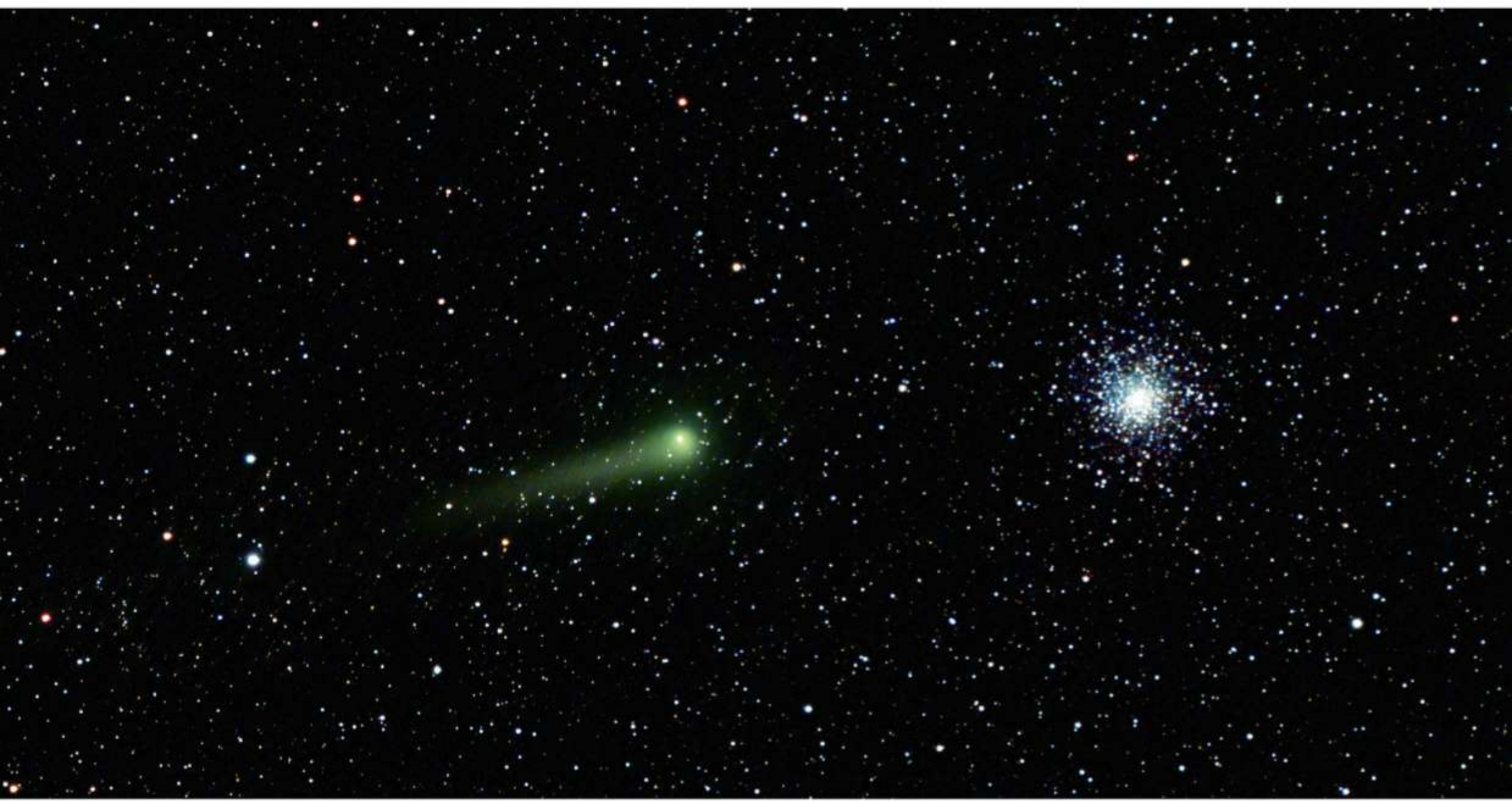
Equipment: Altair Hypercam 269C camera, Altair 8-inch Ritchey–Chrétien, Celestron AVX mount **Exposure:** 20x 30" **Software:** SharpCap, APP, GIMP

▽ Comet C/2017 K2 (PanSTARRS)

Martina McGovern, Cambridge, 14 July 2022

Martina says: "I planned the shot in advance, even though there was a full Moon, and the clouds parted for a bit to let me capture this beauty near M10 while it was at its closest approach to Earth. It won't pass by Earth again for perhaps another million years."

Equipment: ZWO ASI294MC Pro camera, Sharpstar 100 QII refractor, Sky-Watcher HEQ5 Pro mount **Exposure:** 54' **Software:** PixInsight, DeepSkyStacker, Photoshop, Topaz DeNoise



△ The Flame Nebula

Kfir Simon, Tivoli Farm, Namibia, 30 July 2019

Kfir says: "This great nebula is often overlooked because it has a very famous neighbour – the Horsehead Nebula – and imaging it has its challenges because of the very bright star Alnitak nearby in Orion's Belt."

Equipment: FLI ML8300 CCD camera, ASA 12-inch f/3.8 astrograph, ASA DDM85 mount **Exposure:** 4h **Software:** MaxIm DL, Photoshop

M13, The Great Hercules Cluster ▷

Patrick Cosgrove, Honeoye Falls, New York, 29–31 May 2022

Patrick says: "I've imaged M13 in the past, but I wanted to try it again and do the best job possible. I captured 8.5 hours of LRGB data and used several methods to maximise the sharpness. I was delighted with the result!"

Equipment: ZWO ASI2600MM Pro camera, Astro-Physics 130mm EDT refractor, iOptron CEM60 mount **Exposure:** 8.5h **Software:** PixInsight, Photoshop

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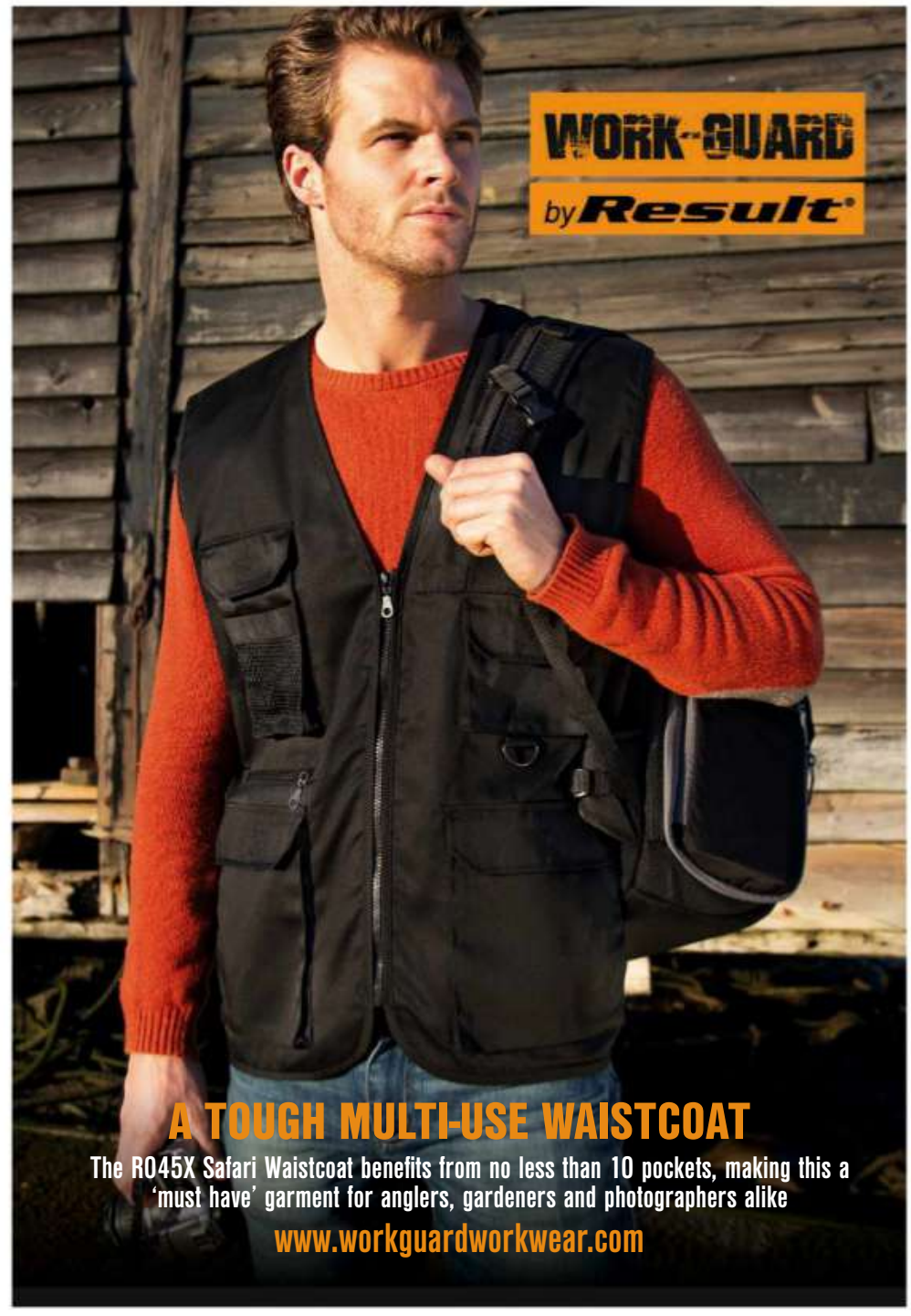
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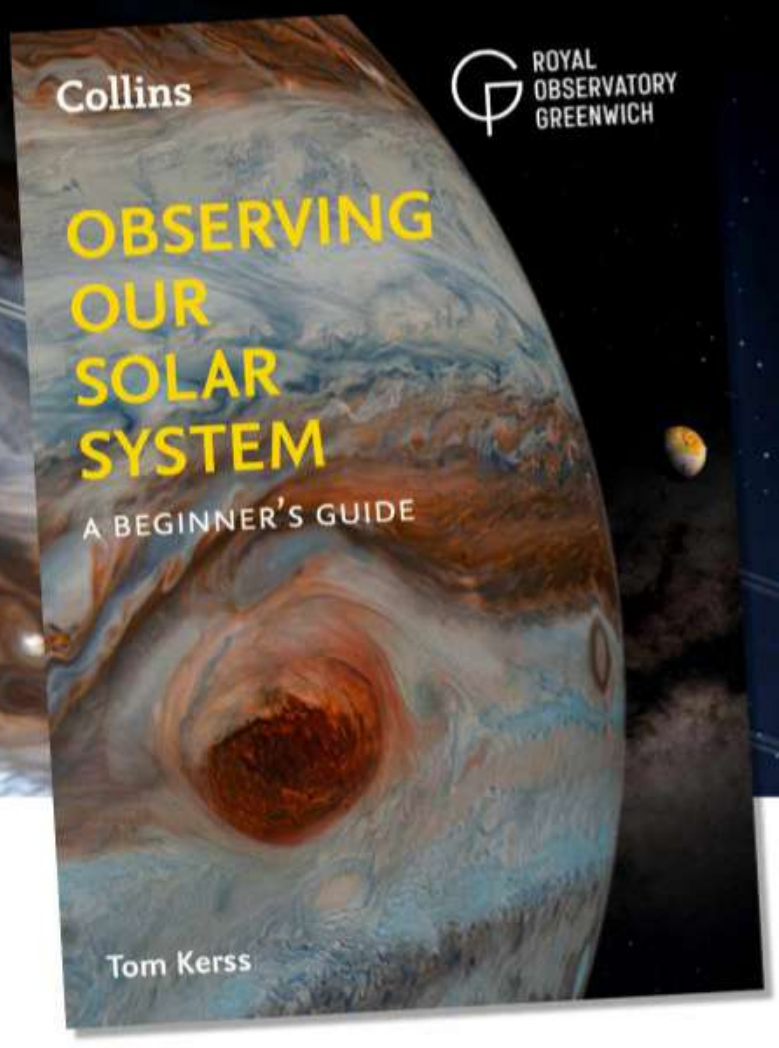

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Askar's 107PHQ astrograph and a mount-tripod combo from Avalon – what did our experts think of them?

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

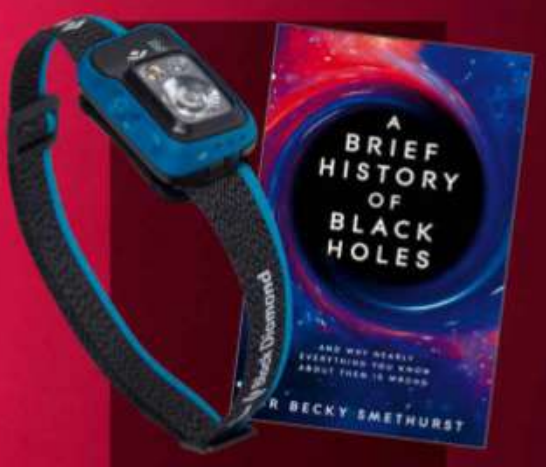
Outstanding
★★★★★

Very good
★★★★½

Good
★★★½☆

Average
★★½☆☆

Poor/avoid
★½☆☆☆



PLUS: The latest cool astro gear and new books on Mars, the Apollo missions, the history of black holes and more

@THESHED/PHOTOSTUDIO

Avalon Evo-Zero mount with T-Pod 70 tripod

A sophisticated – yet sturdy and compact – mounting duo that oozes quality

WORDS: TIM JARDINE

VITAL STATS

- **Price** £3,499 mount; £499 tripod
- **Mount type** Equatorial/ altazimuth
- **Load capacity** 9kg (13kg with optional counter-weights)
- **Slew speeds** 5 speeds
- **Autoguider port** ST4, USB, Wi-Fi
- **Power** 12V to 16V PSU supplied
- **Weight** 13.6kg with accessories; 4.6kg mount; 3kg tripod
- **Supplier** Widescreen Centre
- **Tel** 01353 776199
- **www.** widescreen-centre.co.uk

ALL PICTURES: @THESHED/PHOTOSTUDIO

As more and more advanced telescope mounts become available for amateur astronomers, we were keen to see how the Avalon Evo-Zero stands out from the crowd. Our review package arrived in a single box and included the mount, T-Pod 70 tripod and all the accessories neatly stowed in a sturdy nylon holdall. This is easily carried, weighing only 13.6kg in total. The PDF manual, along with the StarGo software, is on a handy USB flash drive.

The quality of the construction and attention to detail that has gone into the manufacture of the mount stands out. Designed in Italy, it is beautifully machined from solid blocks and exudes understated style. The matching T-70 tripod is stylishly built too, providing a sturdy platform for the mount. It comes with adjustable legs and a very useful carry handle too. Both are clearly products from a company that is passionate about what it does.

The Evo-Zero is designed for astrophotography with short tube telescopes, but can be used for simple visual observing sessions and, with a latitude adjustment range of 0°–90°, as an altazimuth mount, or configured for long-exposure astrophotography. For telescopes up to 6kg, it performs without a counterweight. A 3kg counterweight is included for telescopes up to 9kg. The maximum capacity is 13kg, but this requires the purchase of an additional weight. With increasing telescope loads, slower slew speeds must be observed, and a list of advisable slew rates is included. The mount has no clutches and there is some leeway as regards balancing the optical tube. If balancing is required, the RA axis has an electronic brake that must be manually released via a ridged knob.

Some setup stumbles

Initially the mount appeared to be quite complicated, or at least there was a lot to remember when first using it. The ASCOM-based StarGo software is also not particularly intuitive and we had to refer to the manual repeatedly.

For first light, we adjusted the latitude to suit our location. This is a two-stage process and a little fiddly at first, but once the adjustment pin is installed to fit the desired range, fine-tuning the mount is easy. Setting its location and altazimuth or equatorial configuration must be performed via connection to a PC or laptop, using the StarGo software from the USB ▸

Unique belt drive system

The Avalon Evo-Zero is driven by belts and pulleys, in contrast with the worm gear systems of established mounts and with more recent harmonic drive motors. The benefits of the belt drive are less wear to components, improvements in accuracy, and the elimination of the backlash and errors that are inherent in worm gear systems – all important benefits for long-exposure photography.

Avalon have used high-grade, 400 step motors for both axes, with polymer fibreglass pulleys and steel-strengthened timing belts. No internal maintenance or greasing of the belt drive system is required. The rigidity of the drive allows for a certain amount of flexibility when balancing the telescope.

We found the motors to be quiet and with our small refractor on board we could use the Ultra speed mode for slewing, which was nippy and still very accurate. Turning down the speed gives very fine movement control, perfect for high-magnification viewing.

Hand controller

Basic mount movement and control can be handled by this simple controller for convenience, along with access to the various mount speeds. Electric focusers attached to the StarGo unit can also be operated. Other settings can be altered by holding the small function button.

Holdall

The mount and tripod are neatly stowed in a padded holdall with foam cut-outs, which allow all the cables and controllers to be safely transported together – perfect for travelling astronomers. A set of Allen keys, from 1.5mm to 10mm, completes the package.

StarGo control unit

The brains of the mount are in this unit that bolts to the tripod leg. It has USB, ST4 and Wi-Fi connectivity, with separate ports for attaching auxiliary devices like a DSLR or electric focuser. We'd prefer a single cable to these three separate ones that power the right ascension and declination motors, and electric brake.

FIRST LIGHT

StarGo software

There is no on-board star database, but the StarGo software allows the mount to link to PC-based planetariums like Cartes Du Ciel or the mobile app Sky Safari for choosing your targets. Everything else is controlled within the StarGo user interface. It is ASCOM-based and can be used with compatible software, such as PHD2.

Tripod

The T-Pod 70 aluminium tripod raises the platform to 77cm with the legs extended. It sits on rubber pads on tiltable feet and has a built-in levelling bubble. A single, central bolt with tightening knob holds the mount head securely in place and it is quick to disassemble.

▸ drive. A USB connection cable is provided for this. The mount also creates its own Wi-Fi network and connecting to this it can be controlled via a laptop. It is also useful for visual observing by connecting to the Sky Safari app via a smartphone or tablet.

The Evo-Zero has a Vixen-style dovetail saddle clamp to which we attached our 500mm focal length refractor. By using three stars for alignment, we had a reasonably accurate Go-To capability with just a rough polar alignment. The tracking speed can be adjusted via the StarGo software, or Solar, Lunar and No Tracking modes are available.

For long-exposure photography, more accurate polar alignment is necessary. A separately available kit which attaches to the side of the mount can be used for visual alignment – useful for when you're using the setup without a PC – but the StarGo software includes a plate-solving and polar alignment app, X-Solver. This is very precise even if Polaris is not visible and gives highly accurate Go-To capability. We used the polar alignment routine within PHD guiding software to achieve alignment. We then pointed the telescope at a star in the east, where movement would be most noticeable, locked onto it and observed the guiding graph over a couple of hours. Even with very poor seeing conditions, the guide graph was smooth and steady, and perfectly suited to accurate long-exposure photography.

Overall, we were pleased to conclude that the Avalon Evo-Zero is a high-quality, capable and refined portable mount that should satisfy the demands of discerning astrophotographers.

VERDICT

Assembly	★★★★☆
Build & design	★★★★½
Ease of use	★★★½☆
Go-To accuracy	★★★★½
Stability	★★★★½
OVERALL	★★★★☆

KIT TO ADD

1. Avalon 200mm extender for Evo-Zero

2. Avalon Polemaster adaptor kit

3. Avalon X-Guider guidescope mount

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FIRST LIGHT

Askar 107PHQ astrograph

Detail-rich, pin-sharp views from a scope that wows, whether shooting or observing

WORDS: CHRIS GRIMMER

VITAL STATS

- **Price** £2,499
- **Optics** Quadruplet refractor with twin ED glass elements
- **Aperture** 107mm, 4.2 inch
- **Focal length** 749mm, f/7
- **Focuser** 3.4-inch dual-speed rack and pinion
- **Extras** Tube rings, dovetail bar, finder scope bracket, carry handle, camera connectors
- **Weight** 6.9kg (including case)
- **Supplier** First Light Optics
- **www.**firstlightoptics.com

The Askar 107PHQ is a 107mm (4.2-inch) aperture quadruplet refractor. With a focal length of 749mm, this astrograph is well-suited to photographing medium-sized nebulae and galaxies. Askar's second-largest OTA offering (next to its 130mm), it's also wide enough for larger nebulae, if partnered with a full-frame camera.

The 107PHQ arrived in a single large box that contained a very smart and robust carry case. Opening the case revealed the scope with tube rings and carry handle already attached, in addition to multiple threaded adaptors and instruction manuals. First impressions of the telescope were positive, as there was not a single piece of plastic to be found and even the dew shield is solid aluminium. The scope is white, with a striking green trim that matches the dovetail bar, making for a very impressive-looking setup. It appears well-built and feels very solid, while not being overly heavy.

Setting up the 107PHQ for a night's imaging was a quick task, as attaching a finderscope or guide scope proved very simple. It is fitted with a standard finder bracket, but the carry handle also has a countersunk grooved slot along its entire length, which allowed us to mount our guider tube rings with ease. Attaching a CCD camera was a breeze thanks to the supplied adaptors, so we were able to secure the camera directly onto the OTA. Alternatively, a 1.25-inch or 2-inch nosepiece could be used.

Taking it for a spin

At 5.7kg, attaching and balancing the scope on our Sky-Watcher EQ6-R mount was easy with the 300mm dovetail bar supplied. The only slight issue was that the thumb screws on the tube rings stopped the dovetail bar from sitting fully in the mount saddle, but we found that this could be easily solved by adjusting the tube ring spacing once the dew shield was extended.

First up we slewed over to a 30%-lit Moon and the pin-sharp optics didn't disappoint. Getting precise focus was easy and crater details were very well-defined. Once we had observed the Moon, we moved on to the Great Globular Cluster, M13, and fitted our own 32mm eyepiece into the focuser to test a ▸

ALL PHOTOS: @THESHED/PHOTOSTUDIO

Threaded camera connectors

Attaching both CCD and DSLR cameras was easy as four stackable adaptors are provided to cover a wide range of camera fittings, the M48x0.75 being threaded for filters. A visual adaptor is also included for 2- and 1.25-inch accessories, such as star diagonals and eyepieces.

Tube rings and dovetail bar

The 107PHQ comes fitted with tube rings that are mounted on a 300mm Vixen-style dovetail bar. We found that balance was easily achieved without having to adjust the rings on the bar, even with a heavy camera mounted. The dew shield can be fully retracted with the tube rings attached.

Dual-speed 3.4-inch focuser

Equipped with an extra-large, 3.4-inch, solid metal rack and pinion focuser, the Askar 107PHQ can carry up to 8kg of camera equipment. The focuser is extremely smooth, and small adjustments can be made with ease. It is equipped with a camera rotator that is firm but smooth.

FIRST LIGHT

Carry case

The 107PHQ comes in a very solid aluminium travel case as standard. The case is large enough to take the scope with tubes rings attached, but snug enough to keep everything secure. The twin latches on the case are easy to use and secure.

Retractable dew shield

To combat the damp nights, a solid metal, retractable dew shield is provided. Secured in position with a metal thumb screw, the dew shield is not at risk of slipping and, being metal, will allow for the transfer of heat to the main lens if using a heated dew strip.

First-class flatfield

The Askar 107PHQ is an air-spaced triplet with an inbuilt field flattener, making this scope a quadruplet. Not only this, but two of the main elements are made from ED glass, ensuring exceptional colour correction and focusing.

The 107PHQ has a 44mm imaging circle designed to work with full-frame cameras. During flatfield testing, there was no noticeable vignetting when paired with our full-frame Canon DSLR camera. In addition to no vignetting, we found that the inbuilt flattener gave us a very flat image from edge to edge using both our DSLR and CCD camera. Inspecting each image, there was no sign of coma or astigmatism, with stars appearing round into the corners.

The benefit of the inbuilt flattener in a quadruplet is it removes the need for a precise distance between camera and flattener. This means you won't need to buy additional spacers and you can switch cameras with ease. It also reduces the risk of vignetting as the flattener is built to cover the full imaging circle.

@THESHED/PHOTOSTUDIO X 3, CHRIS GRIMMER X 2

◄ The Cygnus Wall as imaged by the Askar 107PHQ paired with a Starlight Xpress SXVR-H694 mono camera, 10x 15' Ha, 8x 15' OIII

▼ The Crescent Nebula captured with the same setup, 5x 15' Ha, 7x 15' OIII

KIT TO ADD

1. Askar 0.7x reducer for 107PHQ

2. ZWO ASI6200MC-Pro full-frame colour camera

3. ZWO Mini Finder-Guider & ASI120MM-Mini bundle

► deep-sky view. The 107PHQ gave an excellent display, with crisp stars to the very edge of the field of view. When dropping down to our 15mm eyepiece, we were able to resolve stars almost to the core – cementing the 107PHQ as a very pleasing visual telescope.

Nevertheless, Askar's latest quadruplet is sold primarily as an astrograph, so we were keen to test its imaging abilities. Switching out the eyepiece we inserted our CCD to make the most of some late-summer nebulae. Slewing over to Cygnus we homed in on the Cygnus Wall, which at 748mm focal length just fitted into our field of view. We were pleased to find that our CCD achieved focus easily when attached directly to the back of the focuser, with no additional back focus or extension tubes required.

Looking sharp

Once focused and with our autoguider running, we ran some 15-minute test exposures. These confirmed that the stars were round and pinpoint-sharp across the field, with no vignetting visible. With everything set, we left the camera running for as long as the lighter summer skies would allow. Taking advantage of the clear weather, we also spent a couple of nights imaging the Crescent Nebula.

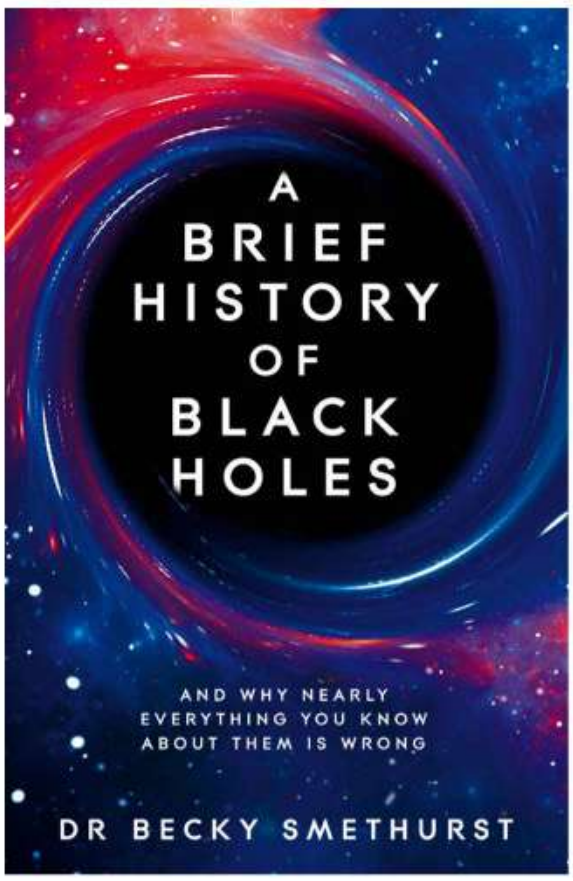
Excited to see our images, we stacked our data and loaded it into Photoshop for processing. Instantly the quality of the astrograph was apparent, as without any flat calibration frames being added, the data was clean with an even background. Getting the best from our images was therefore straightforward, with lots of detail emerging without the need to overprocess.

The Askar 107PHQ is a very rewarding addition to any astrophotography setup, delivering excellent data. However, this larger astrograph will benefit from a sturdy mount to bring out its full potential, making it an ideal tool for seasoned astro imagers.

VERDICT

Build & design	★★★★½
Ease of use	★★★★½
Features	★★★★½
Imaging quality	★★★★★
Optics	★★★★★
OVERALL	★★★★½

BOOKS



A Brief History of Black Holes

Becky Smethurst
Macmillan
£20 ● HB

What do the terms gravitationally collapsed star, frozen star and dark star have in common? They are all terms that have been used to describe black holes. This nice little titbit is just one of the many that fill *A Brief History of Black Holes*.

The book takes you for a jaunt through science history, presenting the smallest to the largest black holes, while travelling from the centre of the Milky Way to the edge of the visible Universe. This is all done with Becky Smethurst's charming wit and many pop-culture references. The chapter titles are cleverly thought out, using song lyrics from the Spice Girls to quotes from *The Lord of the Rings*. Not something you see every day in a popular astrophysics book! In addition to Smethurst's uncomplicated writing style, it makes for a book that's very accessible and an easy read.

The book flows between concepts mostly with ease and is a wide-ranging discussion of all things black holes. There are many footnotes, which could distract a little from the book's main themes. However, we're taught how stars shine, how small black holes and neutron stars are created, and what happens when they collide, as well as what we know about supermassive black holes. The author nicely namechecks key figures in discoveries wherever possible, highlighting the contributions of often overlooked groups. One of the book's strengths is you're likely to read names you have never heard of before.

There are some inaccuracies, however, which a quick Google search would remedy, such as the future LISA space mission being an ESA mission rather than led by NASA, and also its launch date. Elsewhere the description of the make-up of a gravitational-wave detector and which detectors made the first discovery is wide of the mark. Regrettably this put a bit of a dampener on my reading of the book. Nonetheless, if you want to uncover the dark historical event that gave black holes their name and what an ultramassive black hole is – all from a book that feels familiar and will make you giggle in places – *A Brief History of Black Holes* is for you. ★★★½☆

Take a trip from the supermassive black hole at our Galaxy's centre to the edge of the Universe

ALEX-MIT/ISTOCK/GETTY IMAGES

***Laura Nuttall** is a cosmologist and Future Leaders Fellow at the University of Portsmouth*

Interview with the author
Becky Smethurst

What is a black hole?

If I could change anything in all of physics, it would probably be the name for a black hole! A black hole is an object so dense that not even light can escape it, because the gravitational pull is so strong. I describe them as more like a 'dark star' than a 'hole'. It's a star that's been collapsed down, squished down, until it's so dense that we no longer get any light from it at all.

Is it even accurate to call them black?

Actually black holes are some of the brightest objects in the Universe. They light up like Christmas trees. When material falls towards them, it gets accelerated to huge speeds and starts to glow in visible light but also ultraviolet, X-rays and radio emission. In the centres of galaxies we see supermassive black holes anywhere from a million up to 10 billion times the mass of the Sun, and these things really do shine. They can outshine hundreds of billions of stars and galaxies. It's quite incredible.

So you had a lot of ground to cover?

The main guiding force was looking at the history of our understanding of black holes: where the idea comes from, how we figured out they exist in the first place, our first observations, what we know and what we still don't know. It was easier in that respect because you start at the point when we knew nothing, when the idea of a black hole wasn't a blink in anybody's eye. And while the history can illuminate where the idea of black holes comes from, it also reveals what's left for us to discover.

***Becky Smethurst** is an astrophysicist at the University of Oxford and host of the popular 'Dr Becky' channel on YouTube*

Taxi from Another Planet

Charles S Cockell
Harvard University Press
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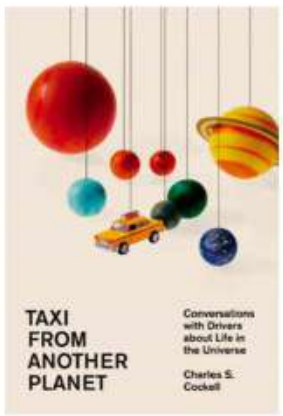

It isn't often a popular science book speaks so directly to the human condition, but this volume achieves something quite extraordinary. Rather than a terse exposition of modern astronomical science, it explores what it is to be human in possession of such copious, fundamental knowledge. Based on brief encounters with taxi drivers the world over, it addresses some of the questions that occur to the lay person, on all aspects of our existence within a perplexing cosmos.

Here you will find no explanations of black holes, the expansion of the Universe or dark matter. Instead the themes tend towards the existence of life – terrestrial and extraterrestrial, the future of space exploration, space tourism and the ultimate fate of humanity.

Refreshingly, it's as much a cultural study as one of astrobiological science, exploring politics, economics, colonialism, ecology and even xenophobia. Occasionally we digress and discover atomic theory, the ghostly quantum nature of matter and existentialist philosophy. But throughout the journey we have in mind the perennial question on the minds of many taxi drivers (and others): are we alone in this vast inky blackness? There are no answers here, of course, but the discussion is fascinating, moving and deeply personal.

Written in amiable and understandable prose, never condescending or judgmental, *Taxi from Another Planet* will be a delight for anyone who has ever pondered their place in the Universe. ★★★★★

***Alastair Gunn** is a radio astronomer at Jodrell Bank Observatory*

The Red Planet

Simon Morden
Elliott and Thompson
£9.99 ● PB

Imagine a world where there was once a vast ocean that almost covered one hemisphere, but which is now cold and arid. Where the atmosphere was once thicker than Earth's, but is now barely there. Where huge volcanoes erupted and giant faults shifted, but these now seem quiet. That world is Mars.

Through colossal planetary impacts, plumes of magma sweeping beneath the crust, stalled plate tectonics, a lost magnetic field and atmospheric constituents continuously trickling away into space, we discover a planet that has seen drastic changes since it first formed. In *The Red Planet*, Simon Morden takes us on that journey from formation through the Noachian, Hesperian and Amazonian eras of Martian history, striving to explain how we may have ended up with the Mars we see today, before looking to the future and our exploration and, potentially, exploitation and colonisation of Mars.

With a wonderfully crafted narrative, the book is easy and enjoyable to read. However, what really stands out are the short novelettes interspersed between the more mainstream scientific prose. Through these the reader is transported to the surface of Mars in the guise of an astronaut on a mission to take samples or readings from these past eras. These are wonderfully descriptive and ingeniously immersive, so it's no wonder that Morden is an acclaimed science fiction writer. Perhaps the only downside to the book is that there could and should be more of these fictional episodes. Fantastic. ★★★★★

***Penny Wozniakiewicz** is a lecturer in space science at Kent University*

Apollo Remastered

Andy Saunders
Particular Books
£60 ● HB

SPACE HISTORY

Between 2008 and 2018, NASA worked to digitise the original filmstock from their early crewed programmes, working at a finer resolution than the grain of the original negatives allowed. After reviewing the entire archive of over 35,000 images, the author of this new book has used the latest image processing and stacking techniques to present hundreds of amazing photos, often managing to carefully tease out more details than we've seen before.

After a brief introduction and selection of images from pre-Apollo flights, the majority of the book is divided into the individual Apollo missions. Each begins with a two-page outline of the astronauts, their missions and what they were tasked with photographing. This is followed by page after page of images shown at their very best. A final section details the original camera equipment used and explains processing techniques and goals.

The difference between the images then and now is often striking. The famous 'A Man on the Moon' photograph of Buzz Aldrin for example, with Armstrong and the Lunar Lander reflected in his visor, now has a warm golden quality from the light reflected by the thermal blankets.

Image captions contain a wealth of information and also mention whether a picture has been included out of chronological order or has been rotated or cropped. For some of the panoramas, the facing page folds out to give an uninterrupted three-page spread.

The result is an authentic and highly engaging look at what it was like to fly such an advanced programme in what is now vintage machinery. ★★★★★

***Mark Bowyer** is a science writer and an expert in the US space programme*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Celestron tabletop tripod for NexStar mounts

Price £149 • **Supplier** Widescreen Centre • **www.widescreen-centre.co.uk**

This is a great grab-and-go tripod that's just 28cm long when folded up. The mounting plate is designed specifically for NexStar SE and Evolution mounts and its 3kg weight makes for a stable base.

2 Black Diamond Spot 400 headlamp

Price £40 • **Supplier** Black Diamond • **www.blackdiamondequipment.com**

A sleek, low-profile design means this head torch won't tip forward or bounce much when you're on the move. Both red and white light options can be dimmed to get the perfect brightness for your needs. Comes in a variety of colour trims.

3 Altair Ultra 3nm H-alpha narrowband 2-inch filter

Price £399 • **Supplier** Harrison Telescopes • **www.harrisontelescopes.co.uk**

ADVANCED This high-end H-alpha narrowband filter transmits 90 per cent of the light in its designated wavelength and 0.01 per cent outside it. Each is individually tested and comes with a report guaranteeing its performance.

4 Rocket night light

Price £11.95 • **Supplier** Not On The High Street • **www.notonthehighstreet.com**

The soft glow of this rocket-shaped lamp makes it a perfect night light to help lull the space-loving child in your life to sleep. It's battery-powered, so you can take it with you for overnight stays and sleepovers.

5 Trewortha bamboo base layer

Price £52 • **Supplier** BAM Bamboo clothing • **www.bambooclothing.co.uk**

A good base layer helps maintain your temperature throughout a night's observations and this one is 68 per cent bamboo fabric, a sustainable alternative to synthetic fibres. The set comes in three colour choices with men's equivalents also available.

6 Protostar FlockBoard

Price from £4 • **Supplier** First Light Optics • **www.firstlightoptics.com**

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Ezzy Pearson interviews Nancy Chabot

Q&A WITH THE DART MISSION COORDINATOR

On 26 September, NASA's DART mission will crash into the asteroid Dimorphos. Its aim is to find out if deflection could save Earth from future impacts

What is the DART Mission?
The DART (Double Asteroid Redirection Test) mission is a very exciting first step for planetary defence. It's a NASA mission that's built and managed by the Johns Hopkins Applied Physics Lab that is purposely crashing a spacecraft into an asteroid to change its motion slightly. DART is just one part of a much larger planetary defence strategy. Key to that strategy is finding asteroids ahead of time. If one was ever discovered to be on course with Earth, this method could potentially deflect it. We're not blowing up the asteroid. Rather, we give it a small nudge, which changes its orbit ever so slightly. When you do this years in advance, it adds up over time so that the asteroid and Earth aren't on a collision course in the future. It's important to say that this asteroid is not a threat to Earth: this is just a test. But it's an important first step.

ILLUSTRATION

▲ After intentionally crashing DART into the asteroid, scientists hope to observe changes in its orbit and ultimately alter its trajectory

Which asteroid will DART impact?
It's actually a double asteroid. The largest one is named Didymos and has a moon that orbits around it, Dimorphos. DART is targeting that small moon. It's just going to change how it goes around the much larger asteroid ever so slightly. The fact that it's a double asteroid is key to enabling the mission. We want to know how much we deflected the asteroid, but the spacecraft will be totally destroyed. Instead, we'll use telescopes here on Earth. These have already been studying this double asteroid system for decades. We know it takes 11 hours and 55 minutes for Dimorphos to go around Didymos right now. We're going to turn back to those telescopes after the impact and they'll tell us how much we changed the orbit time. It's going to be small, maybe about a 1 per cent change, which may be about 10 minutes or so.

What will we be able to see during the impact?
DART is a really focused mission, but it has a camera named DRACO (Didymos Reconnaissance Asteroid Camera for Optical Navigation). It has two purposes. First is to see the asteroid. This asteroid is 160m in diameter and we're targeting it very fast – 22,500km/h. In fact, because Dimorphos is so close to Didymos, you can't actually distinguish them until the last hour of the mission. So DART has to autonomously detect Dimorphos, fire its thrusters and use those DRACO images to ensure an effective collision. The second purpose is to stream images back during its final moments.

NASA/JOHNS HOPKINS/APL/STEVE GRIBBEN

Nancy Chabot is a planetary scientist at the Johns Hopkins Applied Physics Lab and coordinator of the DART mission

Will people be able to see the impact from home?
The telescopes that we're going to use to make this precise measurement of how much we deflected the asteroid have to be state-of-the-art facilities. That said, the distance between Didymos and Earth is minimised during impact to around 17.7 million kilometres, so it will be shining at about magnitude +15.0. If you have a back garden telescope equipped with a CCD camera or other imaging system, you won't be able to make out Dimorphos or the impact itself, but you might be able to capture an image of where Didymos is in the sky. I definitely encourage people to give that a try. We also plan to share the whole kinetic impact event live on NASA TV on 26 September, showing those final images from the DRACO camera until they stop. It's going to be a historic event we get to witness together.

Could it make the asteroid a threat to Earth?
This is one of the beauties of this mission. We're just knocking Dimorphos's orbit ever so slightly closer to the much larger Didymos. It doesn't change how that asteroid system goes around the Sun in any measurable manner, and hence there's no danger to Earth.

How are you feeling, ahead of the impact?
I'm excited. We're taking something from Hollywood blockbusters, asteroid deflection, and making it so we can live in a future where we might have this capability going forward. And it's not just fiction, but reality. We're ready and it's going to be an exciting year to come.

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Get ready as comet C/2017 K2 draws closer and play spot the difference with two triangles

When to use this chart

1 Oct at 00:00 AEST (14:00 UT)
15 Oct at 23:00 AEST (13:00 UT)
31 Oct at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

OCTOBER HIGHLIGHTS

Comet C/2017 K2 (PanSTARRS) is worth following during autumn and summer. Ideal from the Southern Hemisphere, it's setting late in the evening and has possibly achieved 8th magnitude. The comet skirts around the head of the Scorpion, following the Scorpius/Lupus border during October. It slowly brightens as it continues its southward trek, passing through Norma, Ara and concluding the year in Pavo. By then it will be circumpolar from mid-latitude Australia.

STARS AND CONSTELLATIONS

Some constellations have northern and southern counterparts, such as Pisces and Piscis Austrinus. A lesser-known pair, each composed of three main stars, look exactly like their namesakes. Rising in early October evenings in the northeast is a distinctive narrow isosceles triangle of 3rd- to 4th-magnitude stars called Triangulum. Low in the southwest you'll find Triangulum Australe, sitting on its base above the Pointers, with a prominent 2nd-magnitude apex star.

THE PLANETS

Saturn is still well-placed to observe early in the night, transiting around the end of twilight (midmonth) and visible until the early morning. With Neptune and Jupiter at opposition last month, they are well up in the evening hours, crossing the meridian around 23:00 (midmonth). Uranus is rising early in the evening and visible most of the night. Mars arrives just before midnight and transits around dawn. Unfortunately, Venus and Mercury remain too close to the Sun to observe.

DEEP-SKY OBJECTS

This month a visit to the constellation of the Water Bearer, Aquarius, or more specifically to the western end close to the border with the more recognisable roof-shaped asterism in Capricornus. NGC 7184 (RA 22h 02.6m, Dec −20° 49') is an 11th-magnitude, near-edge-on barred spiral galaxy. It has a reasonably bright halo (1x4 arcminutes) with a star-like nucleus. It displays two distinctive stars, an 11th-magnitude star on its northeast end, with another a similar distance due west of its centre.

Move 3° east to discover impressive double star 41 Aquarii (RA 22h 14.3m, Dec −21° 05'). The two components are mag. +5.6 and +6.7, just 5 arcseconds apart. Both should be visible with reasonable seeing and magnification (150x). The real attraction of this double is the colour contrast, one yellow and the other blue.

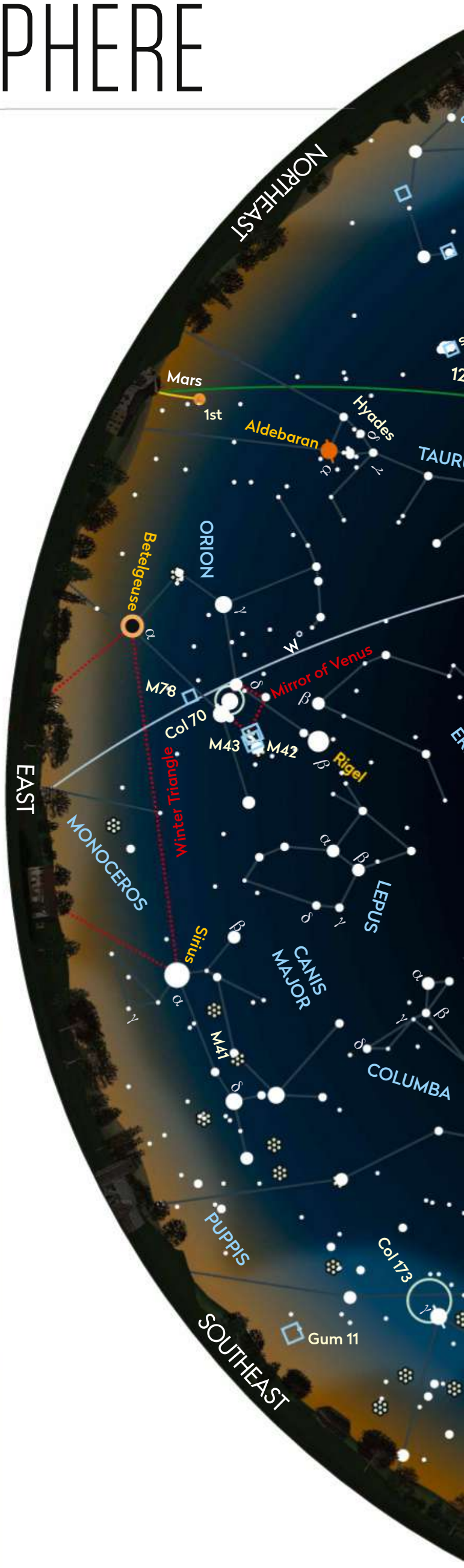

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE

NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
PERSEUS
Algol
M34
ANDROMEDA
M31
M110
M32
NGC 7686
Blue Snowball
LACERTA
CYGNUS
Vail Nebula
Dumbbell
Summer Triangle
TRIANGULUM
NGC 752
M33
PEGASUS
Alpheratz
Great Square of Pegasus
SAGITTA
DELPHINUS
Pleiades
ARIES
PISCES
Ecliptic
Uranus
Circlet
Enif
M15
EQUULEUS
Menkar
9th
Water Jar
Celestial Equator
Jupiter
Neptune
CETUS
M2
AQUARIUS
SERPENS CAUDA
Altair
AQUILA
6th
Denebb Kaitos
NGC 253
Saturn
Saturn Nebula
FORNAX
Helix Nebula
NGC 7184
41
SCULPTOR
PISCIS AUSTRINUS
Fomalhaut
CAPRICORNUS
M11
PHOENIX
GRUS
MICROSCOPIUM
SAGITTARIUS
SCUTUM
Pluto
3rd
CAELUM
HOROLOGIUM
Achernar
INDUS
M55
M25
M16
M17
DORADO
RETICULUM
TUCANA
47 Tucanae
30th
M22
M28
M21
M20
M8
Teapot
Tarantula Nebula
SMC
HYDRUS
PICTOR
Canopus
LMC
MENSA
OCTANS
CORONA AUSTRALIS
TELESCOPIUM
M7
M6
Gum 67
PAVO
VOLANS
South Celestial pole
CHAMAELEON
APUS
ARA
SCORPIUS
NGC 2808
CARINA
Southern Pleiades
MUSCA
NGC 4833
TRIANGULUM AUSTRALE
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